Circular No. 736

The Packaging of American Cotton and Methods for Improvement

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The principal feature of this circular is the discussion of the packaging of cotton at gins in bales of "standard density." The economic feasibility of this method of packaging and its effect on the marketing system for cotton and on the processing of the cotton by mills is covered in detail. Circular 733, Standard-Density Cotton Gin Presses, a companion publication, provides detailed information with respect to the mechanical features and operation of presses employed in this method of packaging.

The Packaging of American Cotton and Methods for Improvement

By John W. Wright, *principal agricultural economist*, and Francis L. Gerdes, *senior cotton technologist, Cotton and Fiber Branch, Office of Marketing Services*, and Charles A. Bennett, *senior mechanical engineer, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

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SIGNIFICANCE OF PACKAGING

The emphasis now being placed on reducing the spread between prices received by producers and prices paid by consumers makes it advisable to examine carefully present practices in the packaging of raw cotton and in handling it in marketing channels to ascertain the possibilities for reducing marketing and handling costs. Furthermore, the increasing competition that American cotton is having to meet in world markets increases the need for improved methods of packing our own product, particularly because most other cotton-producing countries do a better job of packaging their cotton than the United States.

The packaging of American raw cotton has never been entirely satisfactory either from the standpoint of the protection afforded the cotton against loss and damage or of economy in packaging and handling. American cotton bales have long been criticized in the world markets for their unsightly appearance. Furthermore, a number of uneconomic practices, such as the use of unnecessary bale covering materials for the addition of weight to the bales, have long been associated with the packaging of this commodity.

For many years, methods and materials for packaging have been among the most controversial subjects having to do with cotton. This situation is attributable primarily to a clash of interests in providing facilities, materials, and services for the packaging and handling of cotton. The inertia resulting from long-established customs and practices in the cotton industry as well as resistance from those having heavy investment in machinery have tended to make improvements in methods of packaging raw cotton unusually difficult.

Attempts to develop and obtain the adoption of improved methods have also encountered technical problems that have been difficult to solve. Lint cotton as separated from the seed in the process of ginning is an unusually difficult commodity to handle in the packaging process. The loose, fluffy nature of cotton lint makes it necessary to provide a rather elaborate system for handling and conveying the lint cotton to the packing equipment. The resiliency of the lint makes it necessary to provide special facilities for retaining and compacting it, for compressing to desired density, and for retaining that density, and in this way facilitating handling and shipment and providing reasonable economy in transportation and storage.

The bulky nature and weight of the baled product also present special problems in providing wrapping materials that will protect the contents of the bale package and at the same time withstand the wear and tear of shipment and handling in marketing channels. The trade practice of cutting into the package for samples also complicates the problem of providing a satisfactory package.

Packaging and associated services incident to the physical handling of cotton in marketing channels which are directly affected by packaging methods, represent a substantial part of the cost of marketing this commodity. This being the case the problem of improved packaging is one of significant economic importance.

As a background for considering possibilities for improved methods of packaging, present methods and their historical development, as well as methods used in other cotton-producing countries are described in the first part of this circular. The second part has to do with results of experimental and other investigational work recently conducted in an attempt to develop improved methods of packaging American cotton, particularly through compression at gins.[1]

[1] The studies upon which these results are based were made possible through the cooperation of cotton ginners, cotton compressmen, cotton merchants, and cotton manufacturers. Acknowledgment is made of the special assistance of Charles S. Shaw, Jesse E. Harmond, and other staff members of the United States Cotton Ginning Laboratory, Stoneville, Miss., for assistance rendered in the performance of packaging tests reported, and to John M. Cook of the Fiber and Spinning Laboratory, Clemson, S. C., under whose immediate supervision the spinning studies reported were made.

PRESENT METHODS OF PACKAGING COTTON IN THE UNITED STATES

Except for a very minor part which is packaged in round bales of high density, the cotton crop of the United States is initially pressed in low-density presses and packaged in rectangular bales at the gin (table 1). After the bales are turned out at the gin, they are eventually transported to cotton yards, warehouses, or compresses for storage pending reshipment to consuming establishments in this country or abroad. Before shipment to consuming establishments, a major part of the cotton is pressed to higher density at compresses to permit more economical transportation. Usually the bales are compressed to standard density (22 to 25 pounds per cubic foot) for shipment to domestic mills, and to high density (32 to 35 pounds per cubic foot) for export shipment.

Table 1.—*Types of gin presses and number of bales pressed by specified types*

Type of presses	Presses [1]	Bales pressed [2]
Rectangular:	*Number*	*Number*
Single box	848	([3])
Double box	12,237	([3])
Total	13,085	12,296,234
Round	163	3,472
Total	13,248	12,299,706

[1] Data adapted from United States Bureau of the Census. cotton ginning machinery and equipment in the united states, 1940. 43 pp., illus. 1940.
[2] Data adapted from United States Bureau of the Census. cotton production and distribution, 1940. U. S. Bur. Census Bul. 177, 52 pp. 1940.
[3] Data not available.

The Rectangular Bale

Low-density gin bales.—The dimensions of the low-density rectangular bales as turned out at the gin, average about 56 by 28 by 45 inches (table 2). Although a few early model single-box presses that turn out bales 48 inches in length and 27 inches in width are still in use, practically all American cotton is now packaged in gin press boxes with cross-sectional dimensions of 54 by 27 inches. The density of the cotton in these bales averages about 12 pounds of lint per cubic foot but the range in density is from about 8 to 18 pounds, depending upon the bale weight and the moisture content of the cotton.

In 1940, the cotton gins of this country were equipped with 13,085 rectangular presses, of which 93 percent were the double-box type and 7 percent, the single-box type (table 1). About 89 percent of the gins were equipped with up-packing presses, and 11 percent, with down-packing presses.

The principal difference in the up-packing and down-packing gin presses lies in the placement of the pressing mechanism (fig. 1). All modern presses of both types are equipped with hydraulic pressing systems, but some of the older type up-packing presses have a screw mechanism as the driving force in packing the cotton. The piston of the hydraulic ram or the screw of the mechanical system is operated beneath the press; but the ram of the down-packing presses operates above the press.

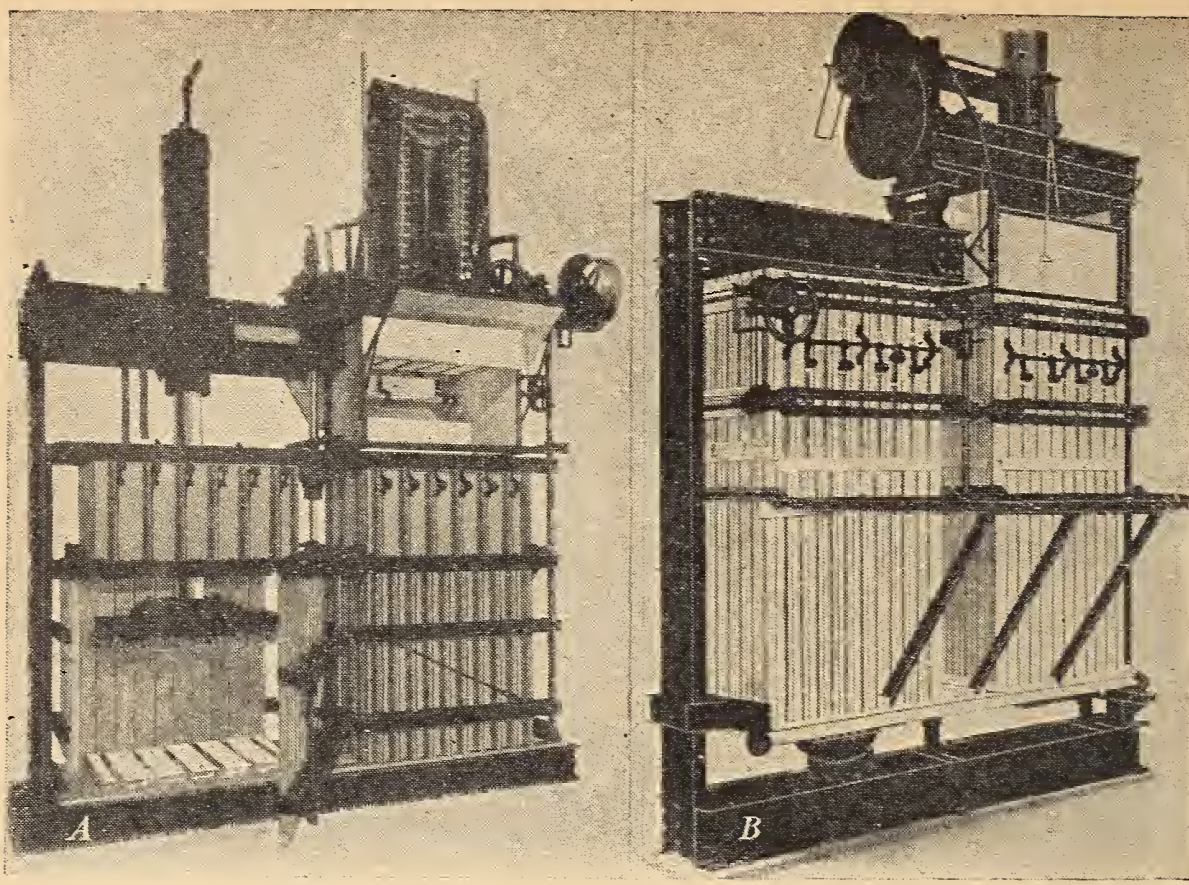

FIGURE 1.—Low-density gin presses of all-steel construction. *A*, double-box single-story, down-packing press; *B*, double-box, 2-story, up-packing press.

TABLE 2.—*Approximate dimensions, weights, and densities of specified types of American cotton bales*

Bale type	Length	Width	Thickness	Weight	Density
	Inches	*Inches*	*Inches*	*Pounds*	*Lb. per cu. ft.*
Rectangular:					
Gin low-density	56	28	45	500	12
Compressed standard-density	56	31	22	500	23
Compressed high-density	57	22	21	500	32
Gin standard-density	56	22	31	500	23
Round	35	[1]22	..	250	32

[1] Diameter.

Presses of the up-packing type are designed primarily for 1½- and 2-story buildings. The arrangement of 1½-story buildings provides for the placement of the ginning machinery on the ground floor, while the gin press is operated from a deck 5 to 8 feet above the level of the ginning floor, the distance from the floor depending upon the depth of the pit in which the pressing unit is installed. In 2-story gin buildings where the gin stands are installed on the second floor, the press deck is on the same level with the ginning machinery. In a few instances, however, up-packing presses have been adapted to 1-story gin buildings by providing a pit approximately 8 feet deep below the floor level to accommodate the cotton boxes and associated pressing mechanism (fig. 2).

When in operation, the ram and press platen on hydraulic presses of the up-packing type travel upward to provide the force required in pressing the bale. After the bale is tied out, pressure exerted

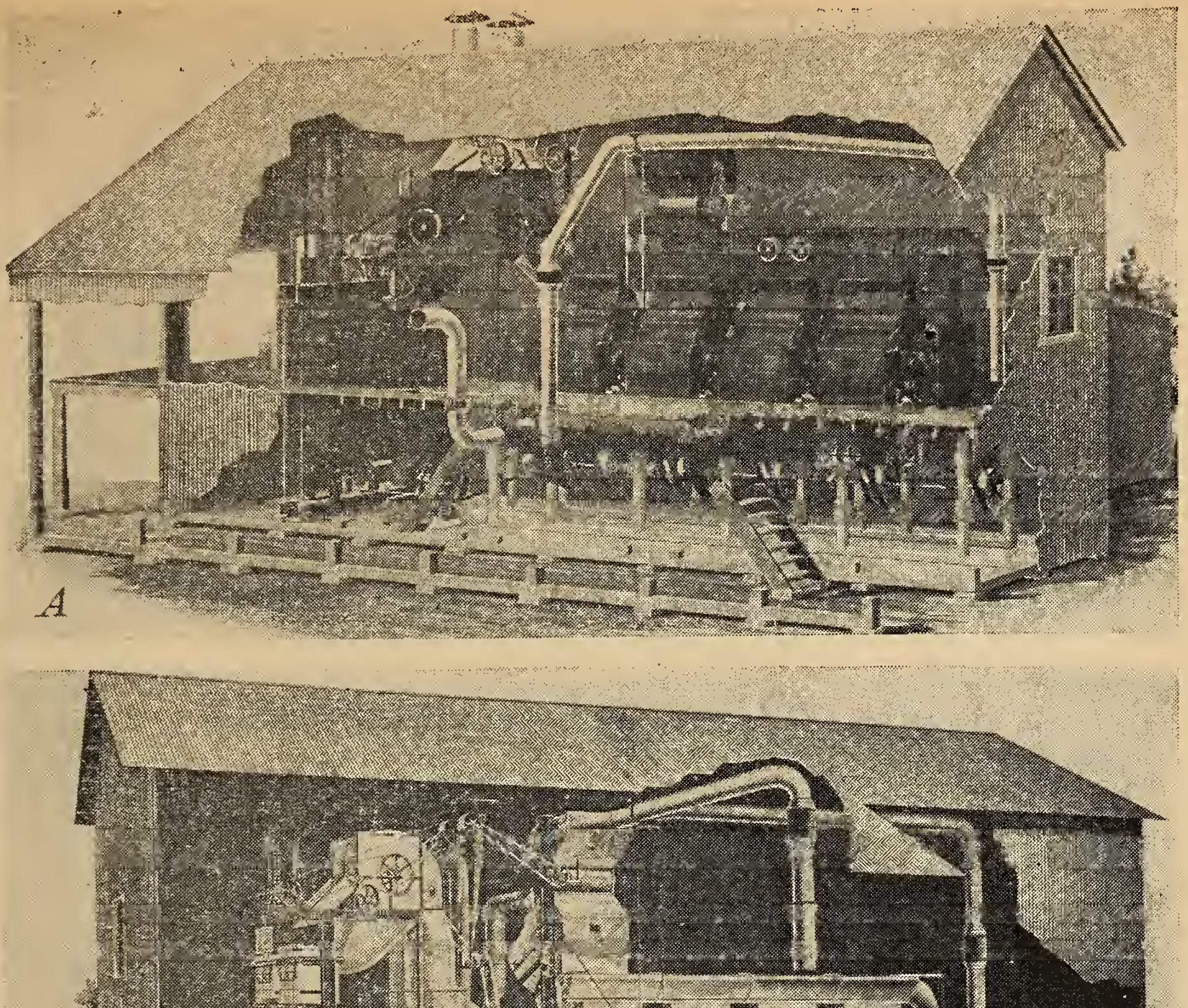

Figure 2.—Different types of gin buildings, illustrating position of ginning and pressing equipment: *A*, Two-story building with press of up-packing type operated on same level with gin stands; *B*, one and one-half story building with press of up-packing type operated from deck above level of ginning floor; *C*, one-story building with press of down-packing type on same floor with ginning equipment.

on the ram is released and the ram moves downward by gravity to its initial position (fig. 3).

Presses of the down-packing type are designed primarily for 1-story gins but they are adaptable also to 1½- and 2-story gin installations. The press-box depth and the ram travel distance are less for presses of this type than for up-packing presses.

The down-packing press is a convenient type for installation in single-story gin buildings, because the pressing ram or other press-

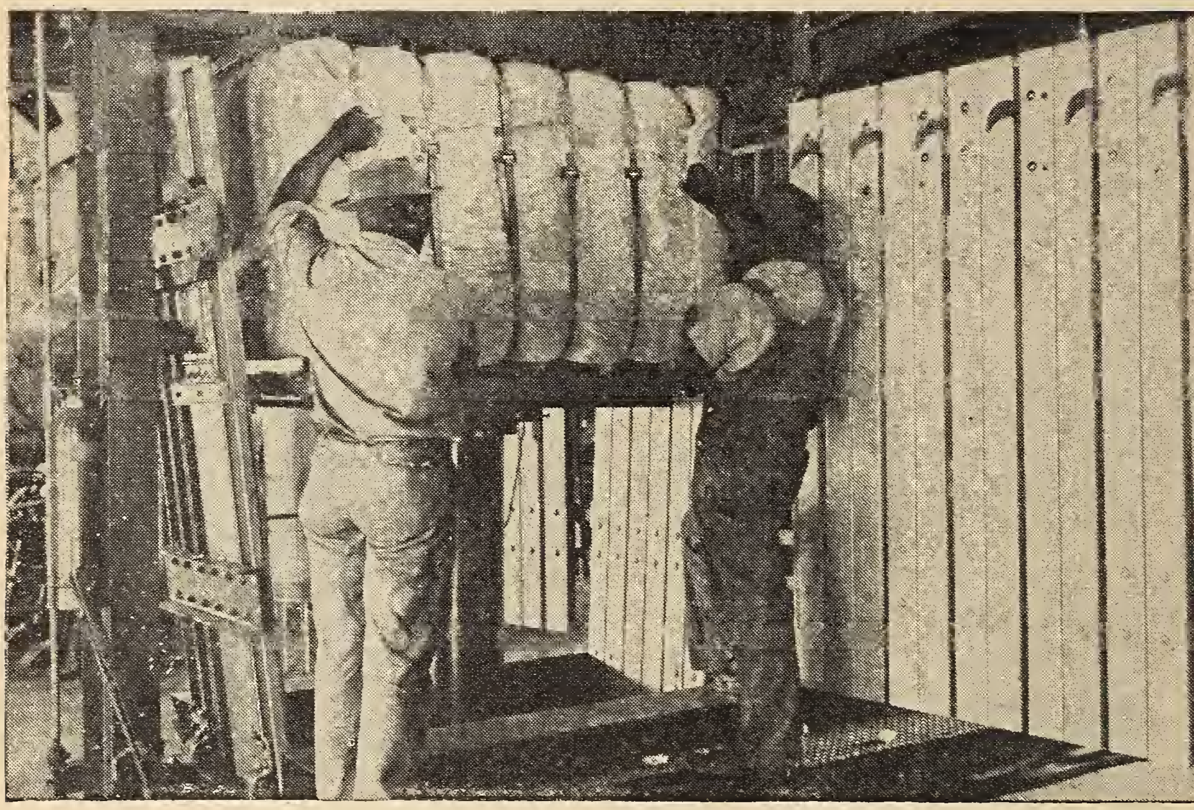

FIGURE 3.—Tying out a bale in a modern low-density gin press of the up-packing type.

ing mechanism is mounted above the press, thereby eliminating the necessity of a pit to house the ram and casing. When in operation, the ram and press platen travel downward to provide the force necessary in packing the bale. After the pressing operation is completed, the ram and press platen are returned to the starting position by the hydraulic system before the press boxes are turned. The hydraulic ram and platen on an up-packing press return to position by gravity when the hydraulic pressure is released, and there is no danger of hydraulic fluid getting into the cotton from the rams as sometimes occurs with down-packing presses because of leakage of oil around the ram packing. In order to prevent leakage of oil and consequent contamination of the cotton, the cylinders or casings on modern down-packing presses are bored and the rams or plungers are provided with piston rings in addition to being fitted with adjustable packing glands on the cylinder heads.

Rectangular gin bales usually are covered with two strips of bagging 108 inches in length and 45 inches in width, and are bound with 6 ties weighing 1½ pounds each. The weight of the bagging varies from about 4½ pounds for cotton bagging to 12 pounds for jute bagging. Trade rules quite generally provide a maximum tare of 21 pounds for gin bales.

Compressed Bales.—Practically all of the cotton produced in the Mississippi Valley and the Southwestern States is compressed to higher density before shipment to domestic mill centers or to ports.[2] These areas of production are of sufficient distance from domestic mill points in the Southeast and in New England, as well as from export points, to make the compression economically feasible through savings in transportation charges that more than offset the expense of compression. Since much of the cotton produced in the Southeastern States is consumed by local cotton mills, the practice of compression to higher density is in many instances not economically feasible. Only 12 percent of the compresses are located in the Southeastern States where 25 percent of the American cotton is normally produced (fig. 4). Furthermore, the average number of bales compressed per press in the Southeast is only one-third of the averages for the central and southwestern regions of the Cotton Belt.

Two methods or degrees of recompression of low-density gin bales are employed, namely, standard density and high density. The relative proportion of bales compressed to standard density and to high density, respectively, depends to a considerable extent upon the relative proportion of bales exported. High-density compression is required for minimum ocean transportation rates for cotton exported to foreign countries. With the decline in exports during recent years, most of the cotton has been pressed to standard density. High-density presses may, of course, be employed in repressing low-density bales to standard as well as to high density. When used for

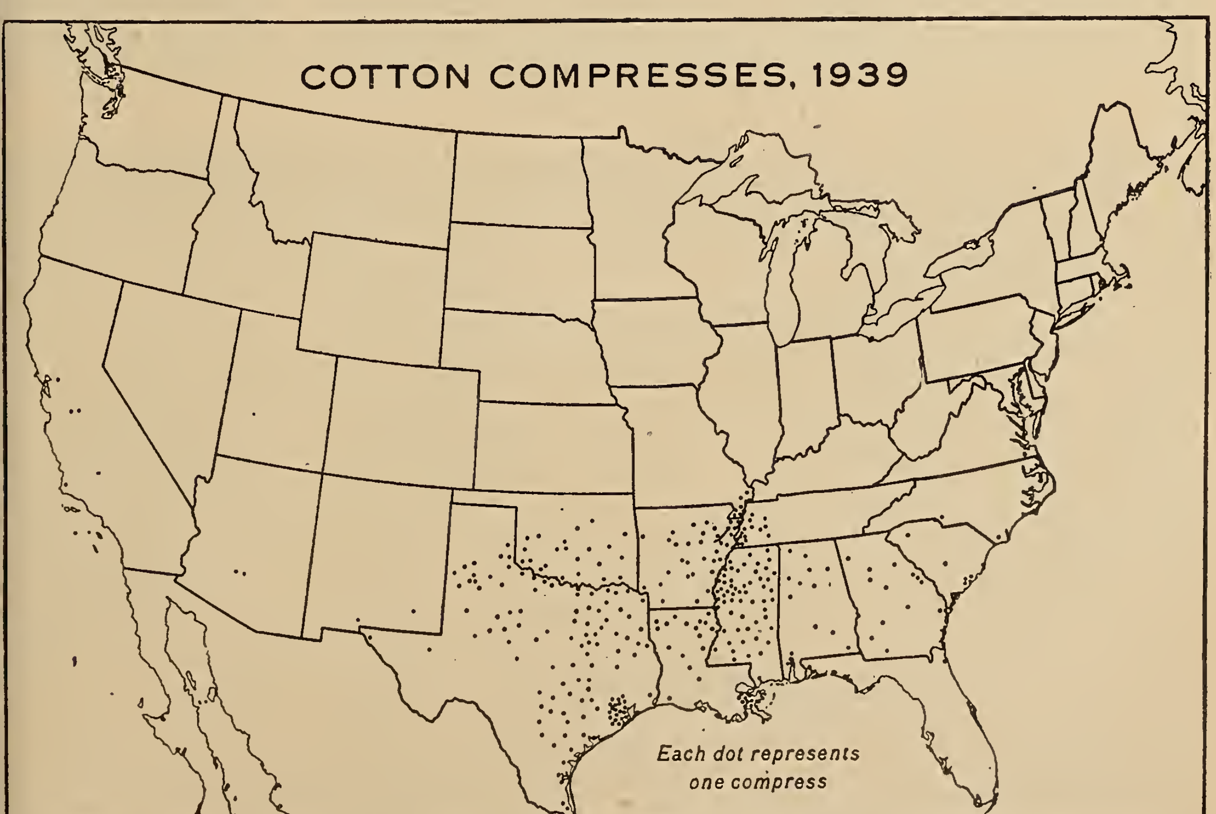

Figure 4.—Location of cotton compresses, 1939.

[2] Wright, J. W. and Bennett, C. A. the compression of cotton and related problems. U. S. Agr. Market. Serv. and Bur. Agr. Chem. and Engin, 68 pp., illus. 1940. [Processed.]

standard-density pressing, the side doors of the press are not used.

More than 90 percent of the compresses now in use operate on the steam-cylinder principle (fig. 5). Of the 358 compress plants in the United States in 1937, 333 were steam-operated, 9 were hydraulic, and 16 were geared-mechanical presses. A newly developed type of triple-ram hydraulic press for repressing low-density

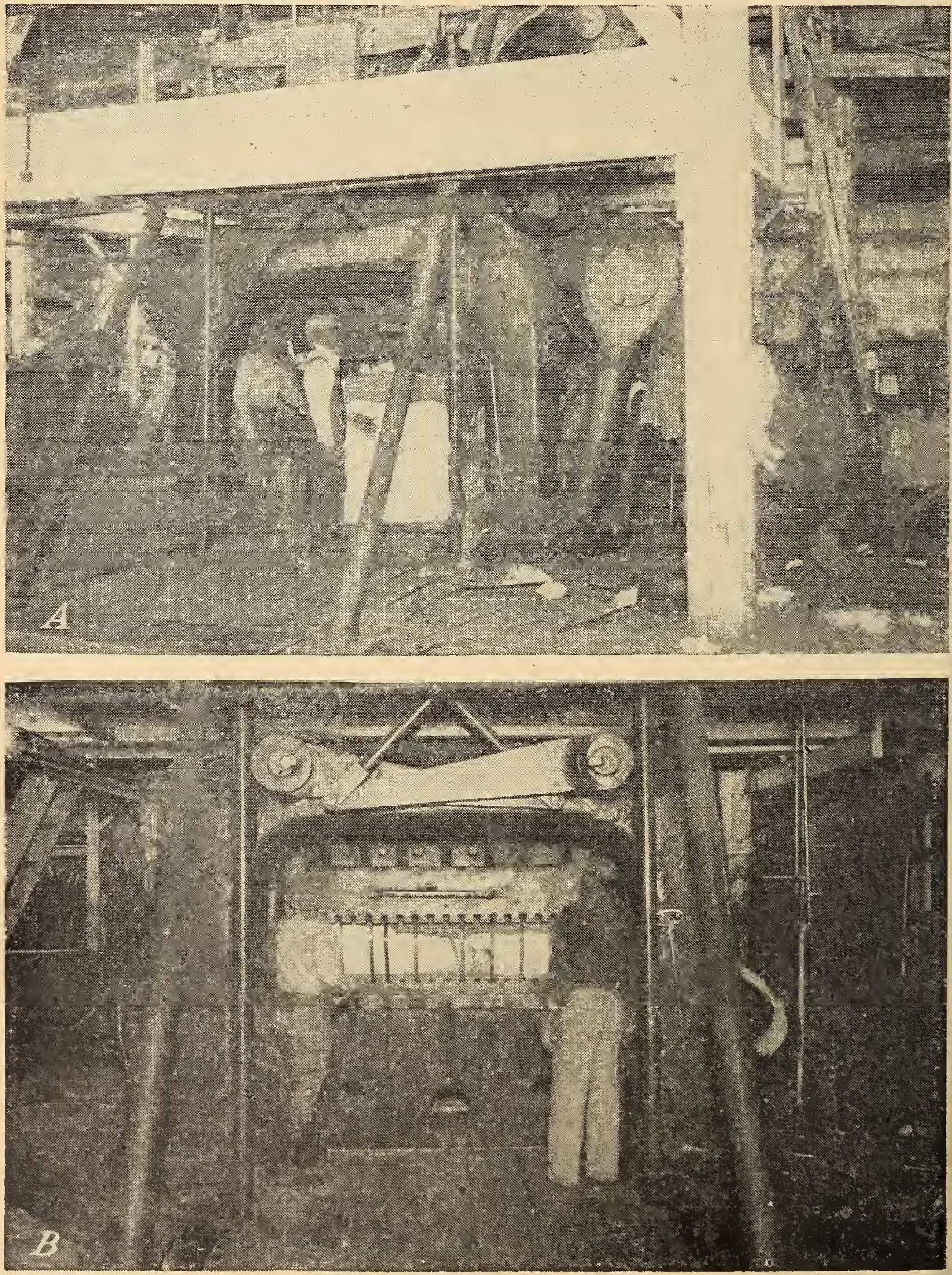

Figure 5.—Steam-cylinder compress. *A*, A gin bale in place immediately before compression; *B*, bale after compression with ties in place and ready to be released from press.

gin bales to standard density has been used to a limited extent during recent years in west Texas.

Standard-density presses are used primarily for repressing cotton destined for shipment to domestic mill centers. Under normal conditions the compression of the bales is delayed until they are to be shipped to concentration centers or to consuming establishments. The accumulation of loan cotton in some areas during recent years has, however, frequently made it necessary to compress the bales upon arrival at the compress in order to conserve available warehouse space.

The average density of bales compressed to standard density for domestic shipment is about 23 pounds per cubic foot. The usual density required in order to obtain minimum transportation rates is 22½ pounds per cubic foot. Standard-density bales average 56 inches in length, 31 inches in width, and 22 inches in thickness, as compared with 56 inches by 28 inches by 45 inches for low-density bales (fig. 6).

It is a customary practice in connection with both standard-density and high-density compression operations to prepare the low-density gin bales for compressing by passing them through a "dinky" press where sufficient pressure is applied to provide enough slack in the ties to permit unbuckling and removal from the bales. The bagging and bale contents are then held in place by means of wire hooks spanning the sides of the bale while it is placed on the lower compress platen, which is then raised by the steam cylinder toward the stationary upper platen to compress the cotton to the desired density.

The essential difference between high-density and standard-density pressing operations lies in the nature of the pressure applied to the bales to produce the required densities. High-density presses employ side doors operated by sufficient force to produce lateral

FIGURE 6.—The four principal types of bale packages employed in the United States: *A*, Flat-gin bale; *B*, standard-density compress bale; *C*, high-density compress bale; *D*, round bale.

pressure on the bales. This reduces their width preceding the application of vertical pressure of the kind used in standard-density pressing. High-density bales, therefore, are narrower by about 9 inches than standard-density bales, and usually are slightly longer. The thickness is the same, or about 22 inches, for the two types of bales (fig. 6).

The high-density bales, having average dimensions of 57 inches by 22 inches by 21 inches, generally approximate 32 pounds per cubic foot. This is the density requirement for minimum ocean-freight rates.

Usually eight ties are used in tying out standard-density bales, and nine ties for high-density bales. Some of the ties used on compressed bales are new but reworked ties from gin bales are used to a large extent. The gin bale ties used on compressed bales are reduced in length from 138 inches to about 102 inches for standard-density bales, and to about 90 inches for high-density bales. Others are formed from the short pieces of ties spliced together. Ties removed from compressed bales at domestic cotton mills are reused to some extent after having been reworked and distributed to compresses.

The usual practice is to fasten the ties on compressed bales by means of heavy-gage wire buckles rather than by the Arrow buckles commonly employed in tying out low-density gin bales. Arrow buckles are used to some extent, however, on standard-density bales. The heavy wire buckles show less tendency to break or to cause shearing of the bands under strain.

As the bales move through marketing channels, they are sampled from one to six times or more, depending upon the number of times the cotton changes hands or the number of buyers involved in the marketing transactions. This practice contributes to the unsightly appearance of much of the cotton when it reaches the consuming establishment. Formerly the sample holes were covered by patches applied during the compression process. Much of the cotton now used by domestic mills is not patched. Although ostensibly the patches are used to cover sample holes, the principal motive of their use is to add weight to the bales by bringing the tare weight up to the maximum allowable under trade rules.

In general, compressed bales do not provide a satisfactory package because of their irregular shape and the careless placement of bagging and ties on the bales that result from the rapid rate at which the compression operation is performed. The open sample holes, incident to the present system of sampling, further detract from the appearance of such bales.

Round Bales

Round bales of high density, usually destined for export trade, are packaged at gins with special round-bale press equipment. The use of round-bale presses, however, is limited to a few gins in the Southwest. Round bales now represent only about 0.01 percent of the cotton produced in the United States. Usually the round-bale press supplements a low-density square-bale gin press to provide an alternative method of packaging the ginned lint. The round-bale press is equipped with its own condenser to which the lint cotton is blown

through a lint-flue take-off pipe. The main lint flue of the ginning system is provided with a valve for diverting the lint either to the round-bale press condenser or the square-bale press condenser. In the operation of the round-bale press, a bat of lint is fed by the condenser to precompression rolls which deliver it either to an accumulator or directly to the roller mechanism of the chamber of the press for winding into a roll of cotton under pressure to provide the density desired. Burlap covering is wound around the completed bale before it is released from the press (fig. 7). Ginning is not interrupted for the discharge of the bale because of provision in the round-bale press mechanism of an accumulator to contain the cotton for the following bale.

Round bales generally have a density of about 32 pounds per cubic foot and weigh approximately 250 pounds each. They are 35 inches in length by about 22 inches in diameter, and are completely covered with burlap bagging during the final pressing operation. The bales do not require ties for holding them intact because the layers of cotton are tightly wound. The weight of tare on round bales is 2½ pounds, or about 1 percent. Under normal conditions, round bales are purchased directly from producers by cotton merchants who ship the bales to foreign spinners. Bales of this type have been used by domestic mills only to a limited extent. Evidently this is attributable primarily to the fact that domestic mills are not equipped to handle these bales in their opening rooms.

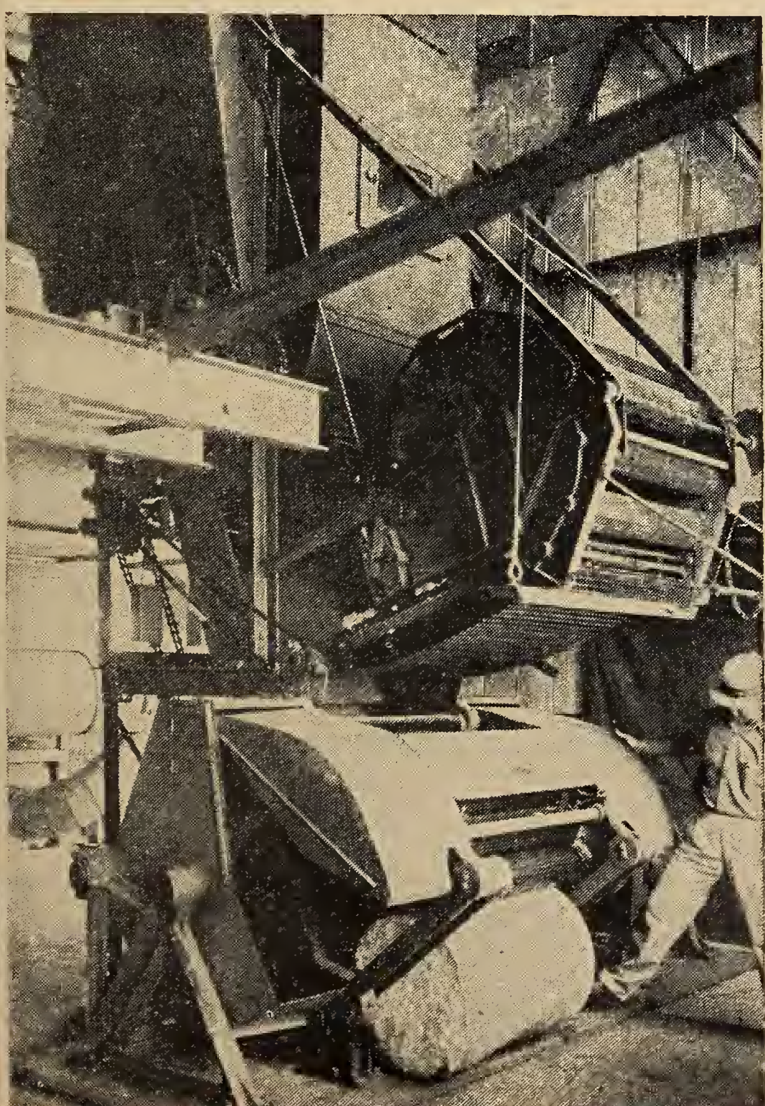

Figure 7.—A bale of cotton being released from a round-bale press.

Round bales are sampled at the gin by the use of an auger or angular "bayonet" sampling device before the bale head is sewn. Round bales, being fully covered and having no sample cuts, are therefore neater in appearance than other types of American cotton bales.

PACKAGING METHODS IN OTHER COTTON-PRODUCING COUNTRIES

There are about 60 countries in the world in which cotton is grown commercially. About 90 percent of the world's cotton, however, is produced in only 6 countries, and of these the United States produces approximately 40 percent of the total and almost 3 times as much as any other single country. The other 5 major cotton-producing countries in the world in order of rank are India, Russia, China, Brazil, and Egypt (table 3). In recent years, these countries together have produced more cotton than the United States.

Table 3.—*Cotton production in specified countries and percentage of estimated world production, seasons 1937-38 to 1942-43* [1]

Cotton season	United States	India	Russia	China	Brazil	Egypt	Total production for 6 countries	
							Quantity	Percent of world production
	1,000 bales [2]	*1,000 bales* [2]	*1,000 bales* [2]	*1,000 bales* [2]	*1,000 bales* [2]	*1,000 bales* [2]	*1,000 bales* [2]	*Percent*
1937–38	18,946	4,788	3,700	3,556	2,075	2,281	35,346	91.5
1938–39	11,943	4,227	3,800	2,300	1,989	1,728	25,987	89.3
1939–40	11,817	4,108	4,000	1,883	2,141	1,801	25,750	88.8
1940–41	12,566	5,090	3,000	2,354	2,507	1,900	27,417	89.7
1941–42	10,744	5,042	[4]2,800	2,406	1,844	1,735	24,571	89.2
1942–43 [3]	12,824	3,727	[4]2,000	[4]2,500	1,966	861	23,878	87.6
6-year average	13,140	4,497	3,217	2,500	2,087	1,718	27,158	89.5

[1] Data adapted from U S. Dept. Agr. AGRICULTURAL STATISTICS, 1943.
[2] Equivalent to 478 pounds net weight.
[3] Preliminary.
[4] Estimated by Office of Foreign Agricultural Relations.

Diverse methods of ginning and packaging cotton are employed in the various cotton-producing countries of the world. Most of the other cotton-producing countries, however, package cotton for export in bales of higher density than the United States, and, in general, foreign-grown cotton reaches the markets of the world in packages that are superior to the American cotton-bale package. The foreign bales are neater in appearance, and the contents are better protected than American bales.

India

India is next to the United States in importance as a cotton-producing country. Normally, India produces about 4 million bales per year.

Practices in packaging cotton vary somewhat in India. Although in some instances ginning and pressing are performed in the same plant, frequently the cotton is ginned in one establishment and pressed in another in the same town (*5*).[3] All cotton for export is

[3] Italic numbers in parentheses refer to Literature Cited, p. 62.

pressed to high density. Bale dimensions are not as well standardized in India as in most of the major cotton-producing countries. Bale weights range from 360 to 500 pounds, with densities of export bales varying from 35 to as high as 55 pounds per cubic foot. The dimensions of bales having densities of 35 to 40 pounds per cubic foot are from 48 to 51½ inches in length, 16 to 20¼ inches in width, and 15 to 18¾ inches in thickness. The dimensions of some of the super-density bales—50 to 55 pounds per cubic foot—are 36 by 30 by 15 inches, whereas others are 44 by 19 by 19 inches. The number of ties used ranges from 6 to 15, depending on the length and density of the bales (fig. 8).

Russia

The production of cotton in Russia has reached about 4 million bales annually in some recent years. The cotton is grown on collective farms, State farms, and independent farms (*11, pp. 67–74*), and is brought to centrally located gins where the seed cotton is graded and stored in bulk prior to ginning. The ginning establishments are large and operate on a year-round basis. Cotton for export is pressed in these gin plants, and the bales are covered with jute or hemp (fig. 9). The package is bound by 5 to 8 wire ties. Bale dimensions are 39.4 by 24 by 28 inches, with an average weight of about 400 pounds per bale and an average density of about 26 pounds per cubic foot (*5*).

China

Most of the cotton produced in China is consumed in the domestic manufacture of clothing. Several hundred thousand bales, however, are exported annually under normal conditions. The cotton is con-

Figure 8.—Indian cotton bales stored in Bombay.

veyed from the interior to mills and export centers in baskets, bags, hand-pressed bales, and press-packed bales (*5*). Some of the bales are jute-covered but some are straw-covered. Cotton for export is packaged into what is known as Tientsin bales. The bales have dimensions of approximately 33 by 29 by 19 inches, weigh about 500 pounds, and have a density of about 50 pounds per cubic foot.

Brazil

The production of cotton in Brazil during recent years has been in the neighborhood of 2 million bales per annum, about two-thirds of which generally is produced in south Brazil. Cotton production in south Brazil has increased greatly in recent years. The quality of the cotton now grown in this area has been improved through a cotton-variety improvement program administered by the Brazilian Government. American upland types of cotton are universally grown in south Brazil, but in northeast Brazil, tree cotton is still produced as well as upland cotton.

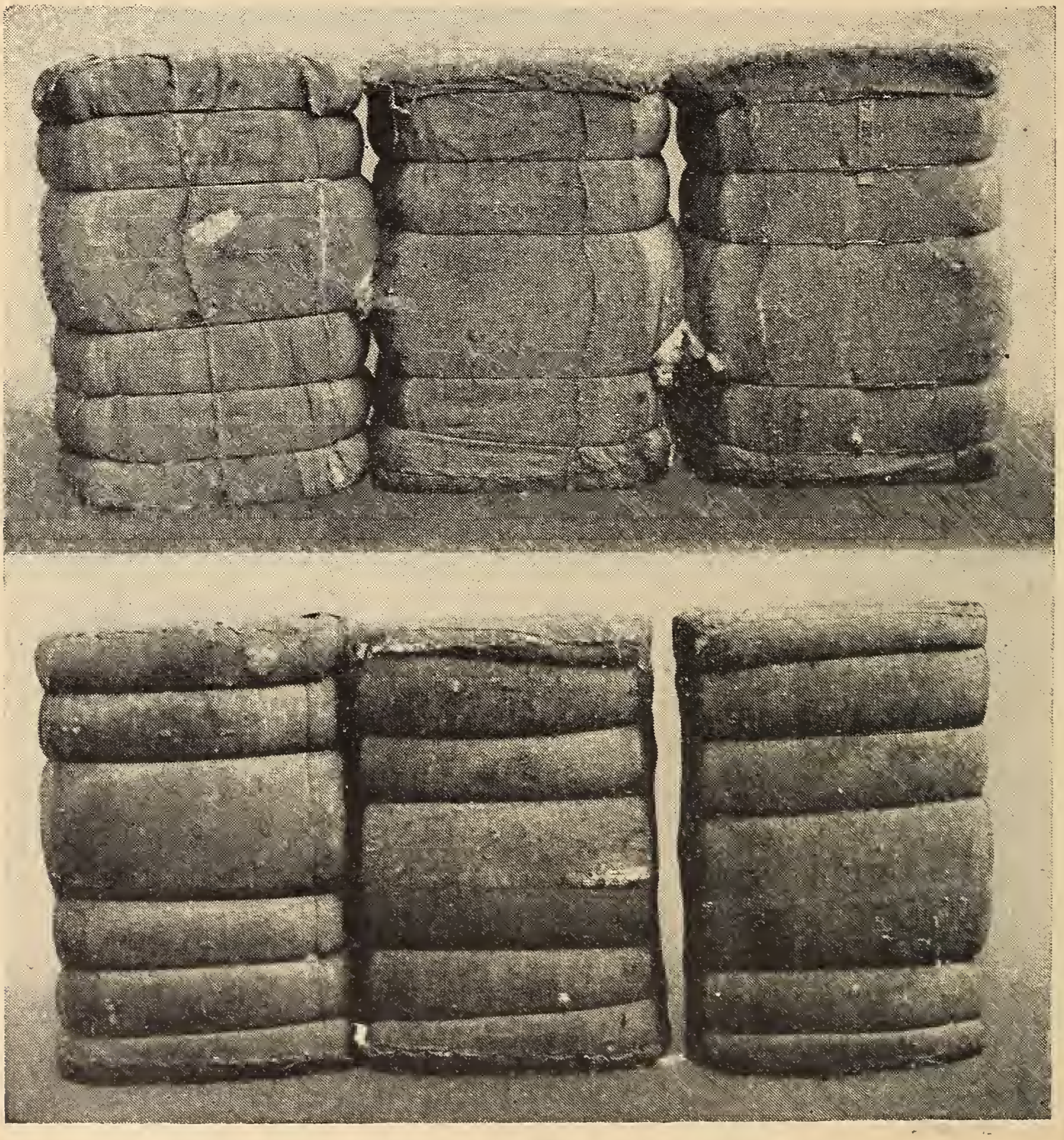

Figure 9.—Bales of cotton produced in Russia.

Modern methods of ginning and packaging are practiced in south Brazil, where 332 up-to-date gins equipped with high-density presses were employed in ginning and packaging the crop in 1939 (*2*). These are hydraulic presses of all-steel construction and equipped with three rams for attaining the pressures required for pressing cotton bales of 400 pounds to a density of about 30 pounds.

Although the bale dimensions of the cotton packaged at the gins in south Brazil are not entirely standardized, the majority of the bales approximate 40 inches in length, 20 inches in width, and 26 to 28 inches in thickness, and they range in weight from 365 to 485 pounds (fig. 10). The density of the bales varies from about 25 to 33 pounds per cubic foot, or is almost as high, on the average, as that for high-density export bales produced in the United States. From 7 to 11 flat steel bands are used in tying these high-density bales. For export, much of the cotton is further compressed to densities of 40 pounds or more at compresses located at the port of Sao Paulo.

Gin plants in northeast Brazil are as a general rule less modern than the gins in south Brazil, and consist in the main of one-stand gins usually with about 50 saws.[4] Many of the gins employ screw presses for packaging the cotton in bales weighing about 200 pounds. When the gin bales reach the coast, they are opened and the cotton is sorted into lots of uniform quality. The cotton is then repacked into bales of high density weighing about 400 pounds each.

Egypt

In Egypt, cotton is pressed at gins by hydraulic presses and released in so-called "soft" bales ranging in density from about 9 to 13 pounds per cubic foot (*3*). The weights of these initial bales range from about 700 pounds upward. Their dimensions usually are either 57 by 45 by 56 inches or 60 by 40 by 56 inches. The bale is completely covered at the gin with closely woven bagging. The bales are bound by 4 or 5 steel bands.

The gin bales are concentrated at warehouses in Alexandria where the bales are opened and the cotton blended into lots of uniform quality for packaging in high-density bales for export. During the process of blending preparatory to packaging, it is customary to sprinkle the cotton with water ostensibly to facilitate compression. The cotton is pressed by hydraulic presses into bales weighing approximately 750 pounds each. The bales are of standard dimensions—52 by 22 by 32 inches—with a density of about 35 pounds per cubic foot. Uniformity in the length and width of the bales is obtained by pressing the cotton in press boxes of fixed dimensions, closed on all sides. Uniformity in thickness is obtained by means of a locking device on the bale ties which prevents slipping and regulates the effective length of the ties. Eleven ties customarily are used. The bagging is applied in several pieces and completely covers the bale (fig. 11).

[4] NORRIS, P. K. COTTON PRODUCTION IN NORTHEASTERN BRAZIL. U. S. Off. Foreign Agr. Relat. 15 pp. 1935. Revised 1939. [Processed.]

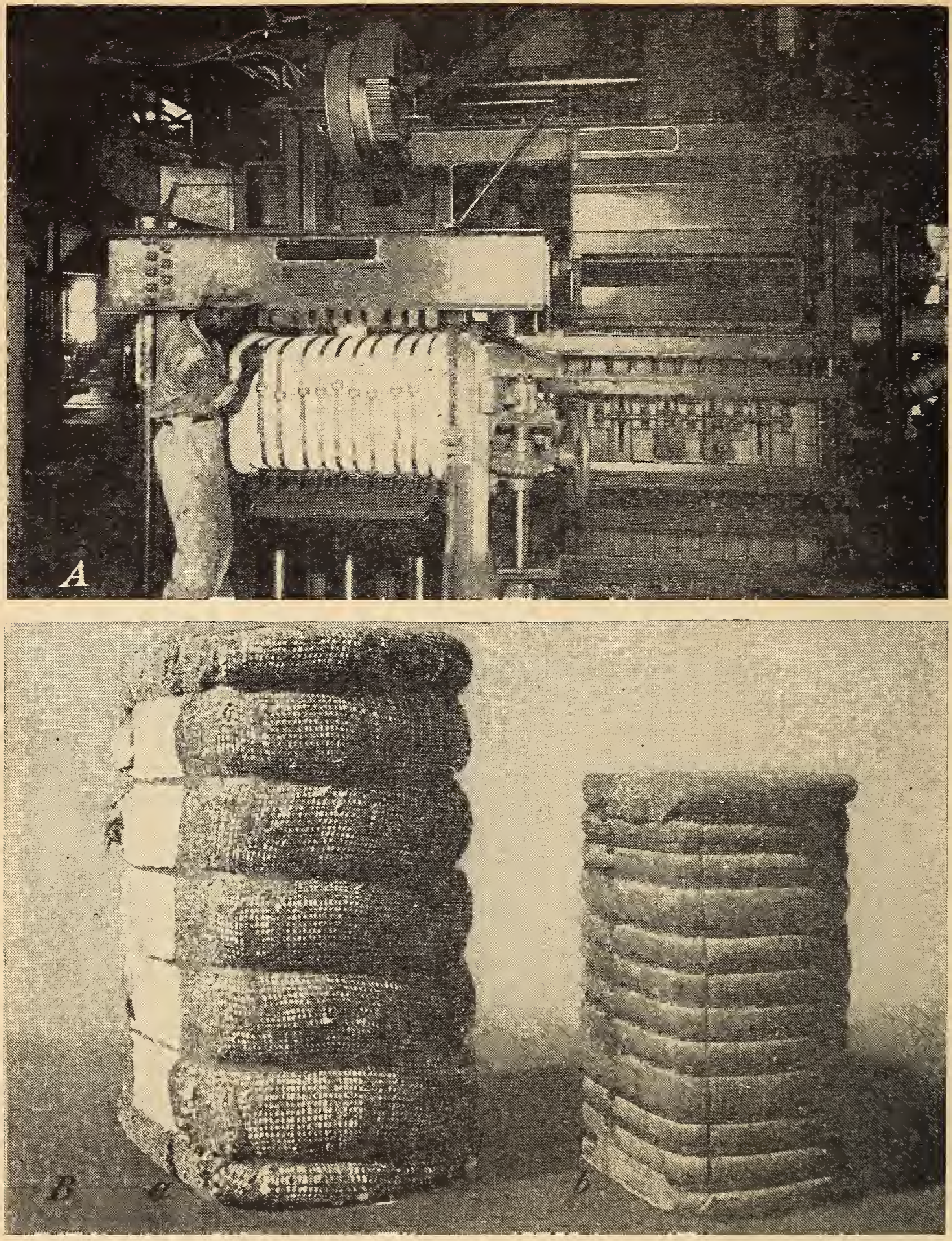

FIGURE 10.—*A*, High-density gin press of the type used in South America for packaging 400-pound high-density bales; *B*, *a*, a regular low-density gin bale, as compared with *b*, a bale packaged in this press.

NEED FOR IMPROVEMENT IN METHODS OF PACKAGING AMERICAN COTTON

Improved Appearance of Bales

In general, foreign-grown cotton reaches world markets in better condition than American cotton insofar as the appearance and condition of the bales are concerned. The bales of most foreign coun-

tries are of higher density and are more adequately protected by the bale coverings than American bales. This superiority in packaging results from the exercise of special care in packaging in some instances as well as from Government requirements for certain standards of packaging in others. The neat package of some countries is feasible because of the availability of cheap labor in handling and pressing cotton at gins and at export centers, but perhaps more particularly because of the eagerness on the part of some countries to improve the competitive position of their cotton in the world markets through better packaging. In other words, the principal basis of criticism of American cotton, which relates to packaging, is being effectively exploited by competing countries.

Little attention has been given to the problem of improved packaging in this country because, until recent years, there has been a ready market for American cotton abroad in spite of deficiencies in its packaging. The system of packaging in bales of low density at gins, sampling of bales each time the cotton is offered for sale or changes hands, and recompression at compresses without use of suitable patches for covering sample holes or for replacing damaged bagging are the principal factors contributing to unsightly appearance of American cotton. Haphazard methods employed in the placement of the bagging and ties during recompression at compresses are also responsible to some extent for the poorly packaged bales.

When typical American bales received at foreign ports, are compared with bales produced in foreign countries, it is evident that the packaging methods prevalent in the United States leave much to be desired from the standpoint of uniformity in bale shapes and protection of their contents (fig. 12).

The responsibility for solving the problems incident to the packaging of cotton in the United States rests with cotton growers, ginners, compressmen, and cotton merchants. American cotton could reach world markets in better condition if growers would insist upon the packaging of their product in a creditable manner, if ginners would give close attention to pressing and use a good quality of bagging, and if compressmen would exercise more care in the placement of bagging while bales are being compressed in their establishments. Proper patching of sample-cut bales to protect the bale contents is the responsibility of merchants as well as compressmen.

Prevention of Damage to Bales

The practice of gin compression, accompanied by complete coverage of bales with bagging and the employment of discriminate sampling methods in other cotton-producing countries, have resulted in improved bale packages not only from the standpoint of appearance, but also from that of preventing damage to the cotton and reducing the fire hazard. In the United States, the exposed surfaces of cotton bales are always subject during handling to damage and stain from rust and paint from the ties, and from sand and other foreign material with which the bales come in contact. Extra costs in removing the damaged cotton from bales at mills, and the losses involved, add to the cost of cotton used in mills, and under most circumstances, adversely affect prices received by growers. The

practices employed in the process of recompression contribute further to bale-package damage. Frequently bagging is badly torn through use of hooks or careless methods in handling the bales. Furthermore, the bagging and the cotton frequently are cut during compression to the extent of making the cotton appear damaged.[5]

The bale cuts made during compression, commonly referred to as "air cuts," range from 1 or 2 inches to 12 inches or more in length and depth. Sometimes as many as 20 cuts occur in a single bale. Even the bales that contain only a nominal amount of cutting appear to be badly damaged. Although tests have shown that the effect of cutting on the spinning value of cotton is almost negligible, the damage to the bale package, and the extra costs attributable to loss

Figure 11.—Egyptian bales stored in a warehouse at Manchester, England.

[5] For a complete discussion on bale cutting during compression, and factors responsible, see Wright and Bennett, footnote 2, p. 7.

of time and additional trouble during compression, justify a concerted effort on the part of the cotton industry to eliminate such cutting. The cutting occurs as a result of the shearing action of uneven pressures in adjacent parts of the bale, which in turn are caused by the presence within the bale of relatively dense masses of cotton that are built up by the action of the gin press-box "dog" mechanism.

Overweight bales accentuate bale cutting and are responsible to a great extent for damage to bale covering materials during handling and shipment. Usually such bales are more irregular in shape and are subject to more severe damage than bales of normal weight. Lack of standardization with respect to bale weights in the United States, therefore, presents serious problems in packaging and results in unnecessary costs in handling.

Reduced Costs of Handling in Marketing Channels

A greater degree of standardization with respect to bale weight, density, and dimensions would contribute materially to improve-

Figure 12.—Typical American bale package stored in a warehouse in England.

ment in the appearance of American cotton bales, and, at the same time, aid in reducing marketing and handling costs under the present system of packaging cotton. The complex system of handling bales from the gin to the cotton mill, together with frequent malpractices at various stages, are factors responsible for the excessive marketing costs for American cotton. Charges incident to the assembling of cotton for compression, as well as the sampling of the bales several times during the marketing process, add substantially to marketing costs. The duplication of weighing, sampling, and marking services further add to marketing costs. Frequently the necessity for the reconditioning of bales involves extra expense. In the aggregate, a large number of underweight, overweight, rolling, big-ended, excessively sampled, and weather-damaged bales must be rehandled and reconditioned each year.

It is evident that improvements in practices employed by producers, ginners, merchants, and compressmen in the packaging and handling of cotton would result in savings of millions of dollars each year to the cotton industry. Because of the conflicting interests, however, and the pressure under which many of the services are performed, progress in effecting these improvements has been limited.

POSSIBLE MEANS OF IMPROVING THE AMERICAN COTTON-BALE PACKAGE

Progress in improving the quality of American cotton through the planting of improved varieties and the adoption of better ginning methods has tended to make cotton producers conscious of the importance of improved methods and reduced costs in handling the cotton in marketing channels. The cotton industry in general is conscious of its obligation to assist in bringing about improvements in the condition, quality, and appearance of American cotton, thereby enhancing its competitive position in world markets. At present, however, there are a number of obstacles in the way of accomplishing the adoption of various improved methods in cotton handling and marketing practices, particularly as they relate to packaging. Important among these is the reluctance of the cotton industry to discard or modify some of the customs and practices that have long been followed.

The trade practice of multiple sampling of individual bales, and the accompanying mutilation of bale coverings, is characteristic only of the American cotton industry. Bales usually are cut and sampled several times, depending upon the number of times the cotton changes hands in marketing channels. The adoption by the ginning industry of automatic mechanical sampling equipment, which recently has been developed, and the use of the mechanically drawn samples in all cotton transactions, would reduce losses associated with existing methods of sampling.

An adequate system of packaging American cotton ultimately must make provision for standardizing bale covering materials from the standpoint of dimensions, weight, strength, and perhaps other factors. This would bring about the use of lighter-weight bagging for wrapping bales and contribute to economies in transportation. The adoption of net weight trading would do much to encourage this change in packaging.

Of the various possibilities for improving the packaging of American cotton, perhaps the most promising is that of the compression of the cotton at gins to a density suitable for all purposes of domestic shipment. The analysis of the engineering and economic factors involved in this improvement, which follows in later sections, is the basic feature of this circular.

THE DEVELOPMENT OF GIN-PACKAGING EQUIPMENT IN THE UNITED STATES

In colonial days the volume of cotton that could be "hand-processed" was small and as most of it was spun by the owner for his own personal use, very little, if any, was sold or shipped. Eli Whitney's epochal invention of the cotton gin in 1793, however, opened a new era of profitable cotton production for which a ready market was waiting. This immediately created a need for suitable methods of packaging the cotton which, until about 1810, was met by the simple expedient of pushing and tramping the cotton into sacks about 9 feet long that held approximately 300 pounds with a density of about 5 pounds per cubic foot (*6*, *10*). The cotton thus packaged was referred to as a "bag of cotton." These bags were very cumbersome and were loaded on wagons with difficulty.

The demand for a more uniform bale that could be transported satisfactorily resulted in the introduction, about the year 1810, of the wooden screw press operated by horse- or mule-driven sweeps (fig. 13). The cotton box was filled by hand and the weight of two men accomplished the packing by foot tramping. Pressing of the bale to final shape and density was accomplished with the screw. These bales weighed from 200 to 300 pounds and averaged about 8 pounds per cubic foot in density. Improvements in designs of the screw presses continued, and about 1840, iron screw presses of considerably smaller dimensions were introduced.

FIGURE 13.—Old plantation gin house and screw press.

During the 20 years following 1840, suitable clutches and gearing arrangements were added to the screw press so that it could be belt-driven from a steam- or a water-power unit. Tompkins reported that low-density bales of 12 to 13 pounds per cubic foot, weighing an average of about 400 pounds, were attainable with these power screw presses.

Hydraulic cotton presses were in operation by 1841, but the extent of their early use is not known.[6] Because of the abundance of cheap labor in the Cotton Belt, power screw presses and hydraulic presses were not used extensively prior to 1865.

According to Lowry, (*6*) the first attempt to achieve greater bale density at the gin, comparable to present standard density of 22 pounds per cubic foot, was the development of a round-bale press built in 1844 by J. E. Carver and W. F. Pratt. This method of packaging consisted first in compressing a bat of cotton between rollers into a sheet and then wrapping the sheet tightly about a wooden core into a round bale. The use of this press was discontinued, however, because the rollers damaged the fibers. It was difficult to unwind the cotton when the bale was opened; also the center layers of cotton "felted" and reduced the spinning value of the product. Mead's round-bale press of 1847, North's patent of the following year, and numerous other improvements and efforts near the end of the nineteenth century culminated in Bessonette's round-bale press which was put into commercial use (*12*).

Rectangular-bale compression improvements were developing concurrently with these round-bale inventions, and as freight-car space became a problem, giant presses were installed at central points to recompress the gin bale to approximately 22 pounds per cubic foot density. Tyler's patented hydraulic compress came out in 1845 and Patricroft (British) invented a 3-ram press in 1862. The central ram of this press operated first and was followed by the outside rams which cut in at the appropriate time. Burr's intensifier rams, with one ram inside a larger one, was patented in 1867. The Morse steam compress was placed on the market in 1874.

Until the late 1870's, the lint cotton from the gin stands was blown into a large screened compartment, the "gin lint room," and conveyed from there by hand to the press box. According to available information, the first cotton-gin condenser, a highly compact and modified form of gin lint room, for feeding the lint directly to the press box, was invented and used in 1878.

The advent of the Munger double-box screw press in 1884, using down-drop doors and a hydraulic or steam tramper, made continuous gin and press operation possible.[7] Other press improvements followed rapidly.

According to Tompkins, an effort was made in the Southeastern States about 1880 to revise the shape and weight of gin bales from the old standard 400- to 500-pound plantation bale to a new bale size about 18 inches square and weighing only 100 pounds, but having 30 pounds per cubic foot density. It was proposed to produce these smaller bales in a horizontal press somewhat like a hay press

[6] Houpt, J. U. S. Patent No. 2,221; Aug. 21, 1841. U. S. Patent Off. Index of Patents 1790-1873, 2: 771. 1873.

[7] Munger, R. S. U. S. Patent No. 308,789; Dec. 2, 1884. U. S. Patent Off., Off. Gaz. 29: 751. 1884.

and to bind the bale with wire, slip the bale into a canvas sack for shipment, and have the sack returned to the producer. A number of these gin compresses were installed and operated, but commercial conditions were unfavorable and they failed to make headway against the inertia of the old system of trading which was based on the standard 400- to 500-pound bale.

By 1914 several types of square-bale gin compresses had been installed at gins in various parts of the Cotton Belt. The Munger compress (1897 to 1912) produced a 500-pound rectangular bale at densities of 30 to 40 pounds in both 54- by 20-inch and 48- by 21-inch boxes (*8*, *1*). Another attempt at 30-pound densities was the 500-pound folded lap square bale of Thomas, the bat being compressed between rollers and folded into the press box.[8] The Luce Gin Compress, which was used during this period, employed 45- by 25-inch boxes, and was reported to produce 500-pound bales having densities as high as 40 pounds per cubic foot.[9] Other developments included the 250-pound cylindrical lap bale, 40 inches long, to correspond with the width of the picker lap in cotton mills, and the 250-pound end-packed cylindrical bale.

Shortly after the beginning of the present century, a series of international cotton conferences strongly advocated the packaging of cotton at gins in bales of about 35-pounds-per-cubic-foot density as a means for improving the packaging of American cotton and effecting economies in marketing practices. At that time, some American cotton was being packaged in gin-compressed bales (fig. 14).

In 1907, the International Conference of Cotton Growers passed resolutions recommending the adoption of gin compression as a means for improving the packaging of American cotton and effecting economies in marketing practices. In 1908, there were 5 companies manufacturing and actively promoting high-density gin presses for so-called "square" bales, and 3 companies were similarly active in the manufacture and promotion of "round" bale presses. High-density presses had been installed at a considerable number of gins in various parts of the Cotton Belt.

At the sixth International Congress of representatives of Master Cotton Spinners' and Manufacturers' Associations held in Milan in May 1909 (*9a*, *pp. 306-308*), a report was given on Progress Made in the New System of Handling American Cotton. The report described a 500-pound bale measuring 40 by 30 by 24 inches and having a density of 30 to 40 pounds per cubic foot.

Demonstration shipments of gin-compressed bales to European and domestic spinning centers brought official endorsement of the practice by the War Industries Board in 1918 (*13*). The Board recommended to the Railroad Administration that high-density compression at gins be encouraged by providing reduced carload rates on cotton so packaged at gins. With the ending of the First World War, however, the subject did not receive further official attention.

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[8] Thomas, A. D. U. S. Patent No. 699,935. May 13, 1902. U. S. Patent Off., Off. Gaz. 99 (1): 1513. 1902.

[9] Luce, C. J. U. S. Patent No. 864,975. Sept. 8, 1907. U. S. Patent Off., Off. Gaz. 130: 108. 1907.

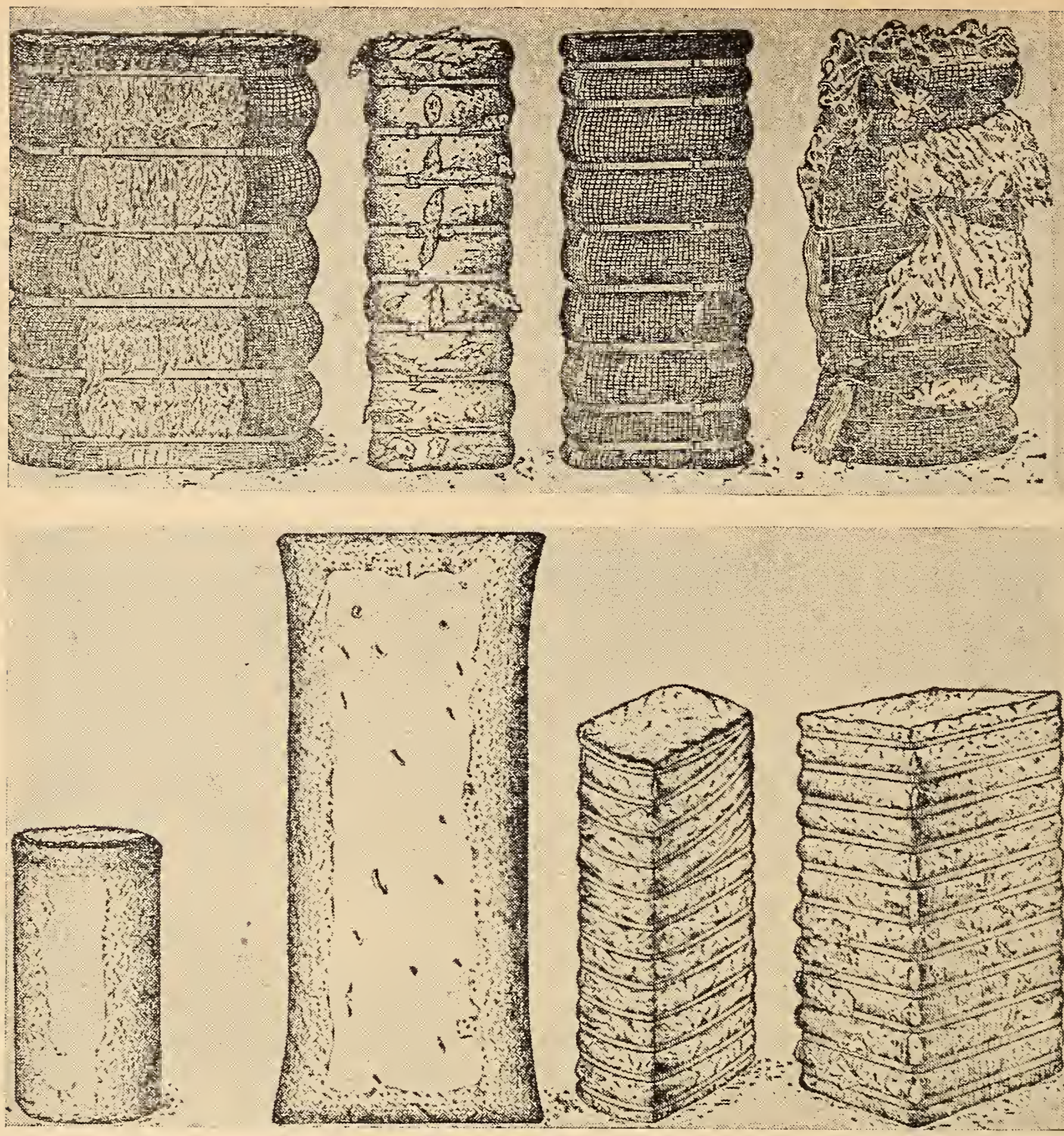


FIGURE 14.—Sketches of several kinds of cotton bales in use in the United States and in certain foreign countries about the year 1900, including (lower right) a 20- by 54-inch gin compressed bale.

At the tenth International Cotton Congress (*4, p. 103*) held at Zurich in June 1920, a resolution was passed as follows:

> Resolved, That this Congress recommends that American cotton be compressed at the gin, ready for export; that a density of not more than 36lbs. per cubic foot be applied and secured by bands and studs which will retain that density in a uniform manner. The Congress views with grave concern the adoption of any method whereby end and side pressure is applied during compression, as in the opinion of the Congress such end and side pressure seriously damages the contents of the bale and renders it in many cases unusable.
>
> The Congress further recommends that the bales be uniform in size, and shape, and weight (as near as possible 500lbs. each net), covered completely with a light Osnaburg or Burlap tare, and generally packed, baled, and covered in as efficient a manner as Indian, Egyptian, or African Cotton; that a mark be put on the bale enabling the user to trace the origin of the press and grower.

Gin compression was the subject of considerable discussion during the World Cotton Conference held in Manchester, England, in 1921 (*9*).

Some of the factors reported as preventing adoption of gin square

bale compression at that time were as follows: (1) Ginning volume of the 20,000 gins was too small to make gin compression economically feasible; (2) sampling problems were encountered because buyers insisted on sampling under their supervision to protect authenticity of samples, and frequent sampling of bales would require bales to go without patching because patching could not be accomplished without rebaling; (3) the lack of adequate warehouse storage facilities would cause the high-density bales to be stored on farms and subjected to moisture absorption during rainy weather. In some quarters it was thought that the high-density cotton would not lose its excess moisture as rapidly as low-density cotton, and that there would be greater danger of fiber damage from this source.

The difficulties connected with the adoption of gin square-bale compression were attributable very largely to the failure of all elements of the cotton industry to give the movement concerted support. Trade opposition, encountered from those interested in recompression plants at cotton concentration points, was recognized as one of the major practical difficulties. This situation could not be overcome since saving and other advantages accruing to producers and ginners through gin compression had not been adequately demonstrated. Progress was further beset by various mechanical difficulties that arose from imperfect pump designs, defective press frames, and general slowness of operation of the presses which precluded their use in the larger capacity cotton gins.

Except for efforts to improve the round-bale press, there was a steadily declining interest in gin compression after 1921. Although the rectangular gin-compressed bale was disappearing from the trade of the United States, the 250-pound round-bale press gradually came into use again after 1919. The proportion of the crop packaged in round bales increased from 0.5 percent in 1919 to almost 3 percent in 1932, after which time, round-bale compression began to show a gradual downward trend to only 0.01 percent of the crop in 1941 (table 4). The number of round-bale presses also declined to 163 presses in 1940 as compared with 255 in 1935.

The principal market outlet of round bales has been in foreign countries. Domestic mills have never been equipped with suitable opening room facilities for handling round bales of high density. The gradual abandonment of the practice of packaging in round bales is attributable primarily to the loss of foreign markets, particularly since 1939. Although round-bale press operations are almost extinct, this type of press was developed in recent years to a high state of mechanical perfection.

In contrast with the lack of interest in gin compression in the United States, other cotton-producing countries, Brazil in particular, have found gin compression to be economically and mechanically feasible. These developments in Brazil have emphasized the need for further investigation of the possibilities of gin compression in the United States under present conditions, especially where the volume of ginning per gin plant is now greater than during the early years of gin compression developments.

The construction of gin presses is now far superior to that employed several decades ago, and improvements have been made in press pumping systems. Investigations have also revealed that the sampling problem can be more adequately solved through automatic

mechanical sampling at gins. Sufficient experimental information resulting from studies made by the U. S. Department of Agriculture in recent years is now available to provide a more definite basis for determining the present possibilities of gin compression as an alternative method of pressing cotton to higher density, particularly for domestic consumption.

TABLE 4.—*Cotton packaged in bales of specified types, United States crops of 1899-1943*

Cotton season	Production [1]	Packaged in—		Percentage of crop packaged in round bales
		Square bales [2]	Round bales [2]	
	Bales	*Bales*	*Bales*	*Percent*
1899-1900	9,393,242	9,140,510	505,464	2.7
1900-01	10,102,102	9,718,056	768,092	3.8
1901-02	9,582,520	9,210,094	744,851	3.9
1902-03	10,588,250	10,097,618	981,264	4.6
1903-04	9,819,969	9,434,865	770,208	3.9
1904-05	13,451,337	13,303,261	296,151	1.1
1905-06	10,495,105	10,355,187	279,836	1.3
1906-07	12,983,201	12,849,091	268,219	1.0
1907-08	11,057,822	10,958,547	198,549	.9
1908-09	13,086,005	12,964,852	242,305	.9
1909-10	10,072,731	9,997,386	150,690	.7
1910-11	11,568,334	11,511,890	112,887	.5
1911-12	15,553,073	15,502,296	101,554	.3
1912-13	13.488.539	13,447,775	81,528	.3
1913-14	13,982,811	13,932,830	99,962	.4
1914-15	15,905,840	15,877,031	57,618	.2
1915-16	11,068,173	11,012,315	111,716	.5
1916-17	11,363.915	11,267,745	192,339	.8
1917-18	11.248,242	11,153.704	189,076	.8
1918-19	11,906.480	11,829,378	154,204	.6
1919-20	11,325.532	11,268,379	114,305	.5
1920-21	13.270 970	13.167,703	206,534	.8
1921-22	7.977.778	7,915,882	123,791	.8
1922-23	9,729,306	9,643,215	172,182	.9
1923-24	10,170,694	10.049,540	242,307	1.2
1924-25	13,639,399	13.482,236	314,325	1.2
1925-26	16,122,516	15,946,955	351,121	1.1
1926-27	17,755,070	17.423,177	663,786	1.9
1927-28	12,783,112	12.507.974	550.277	2.2
1928-29	14.296 549	13.959.296	674.506	2.4
1929-30	14.547.791	14,261,677	572,227	2.0
1930-31	13,755.518	13,493,379	524.277	1.9
1931-32	16,628.874	16.318.189	621.370	1.9
1932-33	12,709.647	12.346.857	725.579	2.9
1933-34	12.664.019	12,360.323	607,392	2.4
1934-35	9,472,022	9,373.392	197,260	1.0
1935-36	10,420.346	10,273.219	294,253	1.4
1936-37	12,141.376	12.000.245	282,262	1.2
1937-38	18,252.075	18,088,704	326.742	.9
1938-39	11,623,221	11,544.231	157.979	.7
1939-40	11,481,300	11,393.705	175.189	.8
1940-41	12,297,970	12,296,234	3,472	([3])
1941-42	10,494.881	10,494,443	875	([3])
1942-43	12,438,033	12,438,033	....	..
1943-44	11,128,524	11,128,524	....	..

[1] Running bales, counting round bales as half bales.
[2] Actual bales.
[3] Less than 0.5 of 1 percent.
Compiled from reports of the U. S. Bureau of Census.

FACTORS INVOLVED IN THE COMPRESSION OF COTTON AT GINS

When low-density gin bales are recompressed to higher density at compress establishments to permit economies in transportation and storage, the type of compression applied depends largely upon the ultimate destination of the cotton. All cotton for export is compressed to high density. For the most part, however, domestic mills are not adequately equipped to handle high-density cotton. Since domestic mills now constitute the principal market outlet for American cotton, it is obvious that gin compression should provide a bale

package of a density acceptable to domestic mills. A gin press capable of providing a package of this type should be of a design that can be integrated with standard gin machinery so as to obviate the need for replacement of existing lint-handling and packing equipment and the entailment of prohibitive costs. Present bale dimensions for the most part must be retained to provide for these economies in installation costs. Spinners' requirements with respect to opening, processing, and the preservation of fiber quality all require careful consideration in the development of gin compressing equipment of suitable engineering design.

Suitable Engineering Design of Press Equipment for Use with Present Ginning Equipment

A 500-pound rectangular bale package, with a tied-out density of 22 to 25 pounds has been found in laboratory and commercial tests to be mechanically feasible and to have advantages over the various types of bale packages now available (fig. 15). A gin press designed to provide this density without the replacement of existing lint condensers, trampers, press pumps, and motors now makes gin compression economically feasible under a wide range of conditions. This design includes a narrowed press box that retains the present bale length to make it possible to use conventional condensers and trampers. A press-box width dimension of 20 inches produces bales that are comparable with the average thickness dimension of compressed standard-density bales. The thickness dimensions of the standard-density gin bales is equivalent to the width dimensions of standard-density compressed bales. (See table 2, p. 4.)

In the design of this press, the width of the press box was reduced from about 27 inches to 20 inches to permit the use of standard, low-pressure gin press pumps. The hydraulic pressure requirements with the 20-inch width press are within the limits of operation of these low-pressure pumps even on extra-heavy bales, while those with wider press boxes exceed the limits of such pump equipment (table 5). Also, with the narrow box press, the ram travel time is slightly less as compared with the wider box presses, making the pressing capacity adequate for large-volume gins. The only disadvantage of the narrow-box press lies in the requirement of increased power in driving the tramper as compared with requirements for the wider-press boxes; but the many other advantages more than offset this disadvantage.

The results obtained from extensive tests on the standard-density gin press for 500-pound bales, in comparison with the 400-pound high-density gin press, the round-bale press, and the low-density gin press, have shown definitely that a 500-pound rectangular bale package with tied-out dimensions of about 22 by 56 by 30 inches and a density of 22 to 25 pounds has technical advantages over various other types of bale packages. This type bale package can be produced by the installation of a press that does not require alterations in gin building and pump layouts. Existing condensers, and trampers, can be used with the press. Also, the 20- by 54-inch press box, producing standard-density gin bales, has been found to be more suitable than other box dimensions, for the reason that it permits

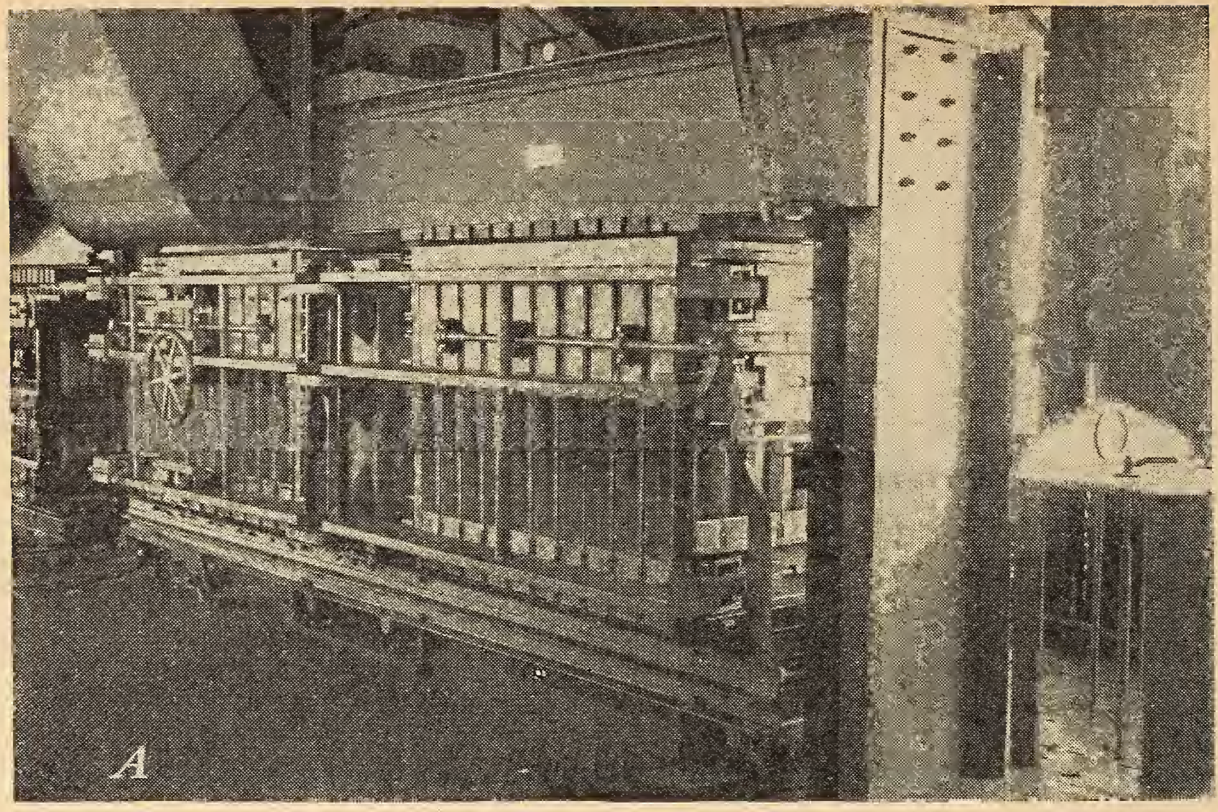


FIGURE 15.—All-steel standard-density gin press for 500-pound bales employed in packaging tests at the United States Cotton Ginning Laboratory, Stoneville, Miss. *A*, General view of the press; *B*, close-up view showing a bale being tied out.

savings in initial costs of pump, press platens, and center column construction. With this design, it is possible to retain existing pumps rather than to have to install special pumps capable of producing higher hydraulic pressures. Three rams of 9½-inch diameter with a 90-inch stroke have been found to provide the densities required with the standard-density gin press for 500-pound bales.

TABLE 5.—*Power and energy requirements of the cotton press as affected by press-box dimensions, bale weight, and other factors involved in the pressing and baling of cotton of normal moisture content to a standard-density of 24 pounds per cubic foot*

Press-box dimensions (Inches)	Bales observed	Bale weight (gross)	Minimum platen separation	Peak hydraulic pressure[1]	Energy consumed[1]			Peak power load[1]	
					Press pump	Tramper and condenser	Press pump, tramper, and condenser	Press-pump motor	Tramper and condenser
	Number	*Pounds*	*Inches*	*Pounds per square inch*	*Kilowatt hours*	*Kilowatt hours*	*Kilowatt hours*	*Horsepower*	*Horsepower*
20 by 54	55	500	21.0	1,804	0.49	0.60	1.09	21.0	12.3
		550	23.0	1,827	.55	.70	1.25	21.2	16.5
		600	25.0	1,850	.62	.80	1.42	21.5	20.8
23½ by 54	18	500	18.3	2,166	.60	.50	1.10	20.2	5.7
		550	20.1	2,621	.60	.55	1.15	21.5	8.2
		600	21.8	3,097	.61	.59	1.20	22.8	10.6
27 by 54	25	500	15.6	2,891	.53	.54	1.07	20.8	4.8
		550	17.2	3,021	.60	.59	1.19	22.0	6.5
		600	18.7	3,150	.68	.63	1.31	23.2	8.2

[1] Data adjusted for variations in bale weight and moisture content.

Hydraulic pressure requirements are significantly less with the standard-density gin press having a 20- by 54-inch box than with the standard-density gin press having a 27- by 54-inch box, both producing 500-pound bales, or the high-density gin press having a 20- by 40-inch box and producing 400-pound bales (fig. 16). The maximum hydraulic pressures encountered with this press on very dry cotton were found to be within the limit of pressures of standard gin pumps of 15 to 25 horsepower, while those having wider press boxes exceeded the limit to such an extent that higher capacity pumps were needed to provide the required pressures.

General specifications for a standard-density press (fig. 17) that would meet the requirements of the United States cotton ginning industry are as follows:

1. *Foundation*—Concrete with pit 9 feet, 6 inches deep by 18 inches wide by 48 inches long for rams; clearance spaces for column nuts.
2. *Rams*—Three 9½-inch diameter by 90-inch stroke. Maximum working pressure 2,600 pounds per square inch.
3. *Casings*—Extra heavy 10-inch pipe or tubing. Head tapped for 1¼-inch pipe thread.
   Frame of press—Capable of withstanding 275-ton load applied over 54-inch center distance of 84-inch to 92-inch span according to manufacturers' standard practices.
4. *Platen beams and bottom sills*—(a) Hot-rolled steel slabs; or (b) 24-inch, 105-pound I-beams; or (c) trussed structural steel framing.
5. *Center column and saddles*—4½-inch diameter at root of threads, 5-inch nominal diameter, SAE Number 1045 steel, with 4- by 10-inch overhung solid slab or built-in structural saddle. Lock collar to support platen beams.
6. *Outboard members, strain rods, and saddles*—3-inch diameter SAE Number 1045 steel strain rods with 2- by 8-inch solid slab or built-up structural saddle. Tramper support column and press frame vertical outboard channel, or I-beam to be attached with fitted bolts of adequate number and size.
7. *Cotton and press boxes*—Cross-section 54- by 20-inch horizontal. Depth 10 feet (120 inches). Dogs—4 per side located out of line with tie channels. Doors—side swinging with wheel latch. Press box taper—¾-inch per door, outward at top. Turntable and box assembly trunnioned on ball or roller bearings.

8. *Platen and followers*—Steel, for 8 flat ties or 11 wire ties, spaced to permit sampling. Followers designed to prevent the tearing of bagging at ram heads.
   Gages and controls—Pressure gage on outboard column of press frame. Valve controls, pump belt shifter or stop buttons located in full view of gage.
   Pump and oil reservoir—Suitable for delivery of at least 12 gallons of oil per minute and capable of withstanding hydraulic working pressures of 2,600 pounds per square inch. Reservoir capacity 150 gallons.
   Tramper—Cut-off gate, and follower of tramper adapted to narrowed boxes of press. Tramper strengthened for heavy-duty packing.
   Pump power—15 to 25 horsepower.

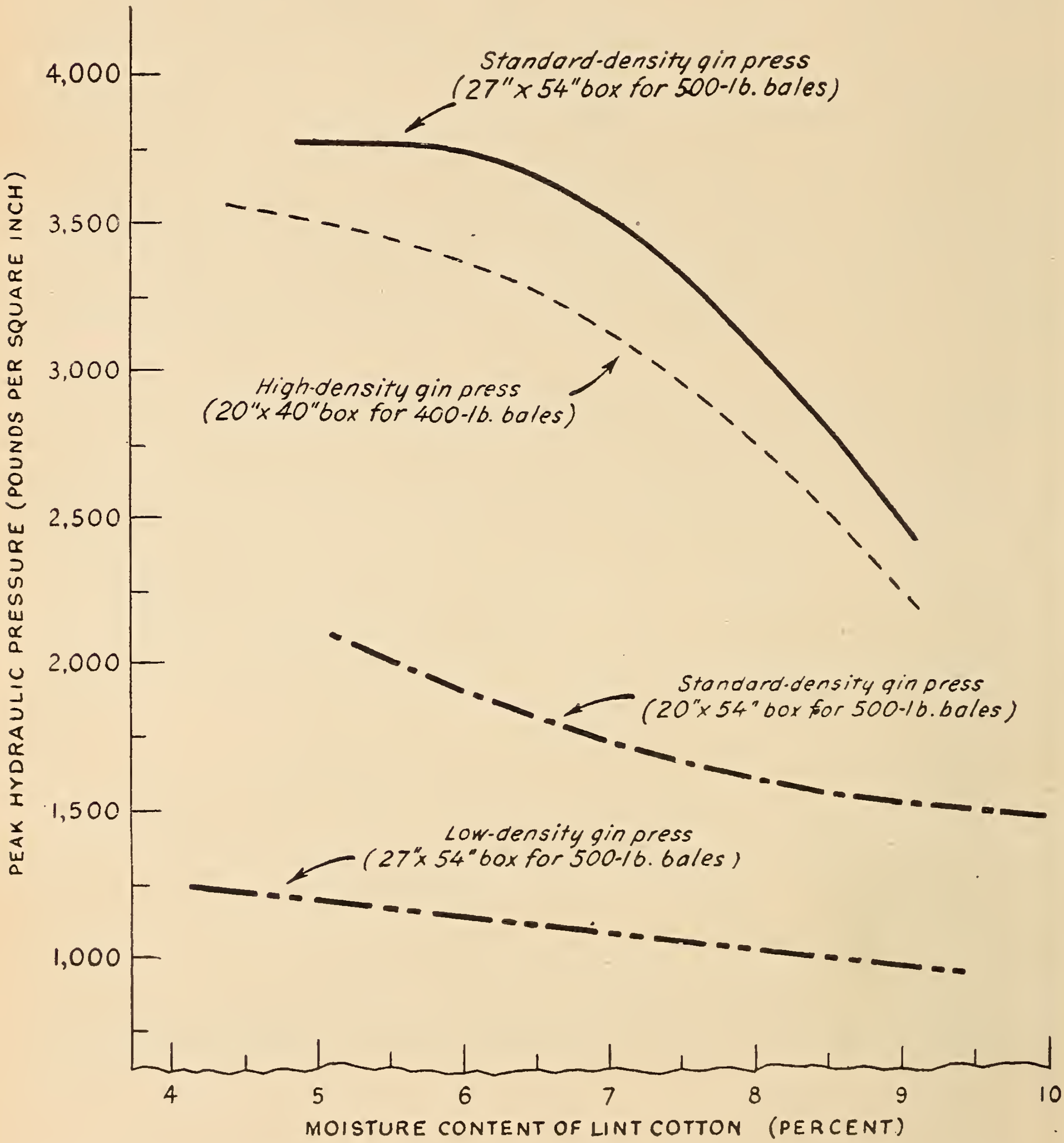


FIGURE 16.—Relationship of moisture content of lint cotton to peak hydraulic pressure attained in pressing bales of cotton to different densities at the gin.

In the light of the results of tests made with an experimental gin press at the United States Cotton Ginning Laboratory, a commercial low-density gin press was converted to a higher density press to determine the economic and mechanical feasibility of converting existing low-density gin presses to presses capable of producing standard-density bales (fig. 18). The converted press was operated suc-

cessfully in pressing a total of 3,300 bales during the ginning seasons of 1942, 1943, and 1944 in a 4-80 two-story gin plant in the Mississippi Delta.[10] The gin bales were reduced sufficiently in size with this press to provide bales of densities comparable with those of standard-density compressed bales (fig. 19). The pressing and tying-out time with this standard-density gin press averaged about 6 minutes, or well within the time required to gin a bale of cotton on a high capacity 5-80 gin outfit. The time required for the pressing operation with a low-density gin press generally was about one-fourth less than that observed for the standard-density gin press operated under similar conditions.

At the converted gin press located in the Mississippi Delta, the

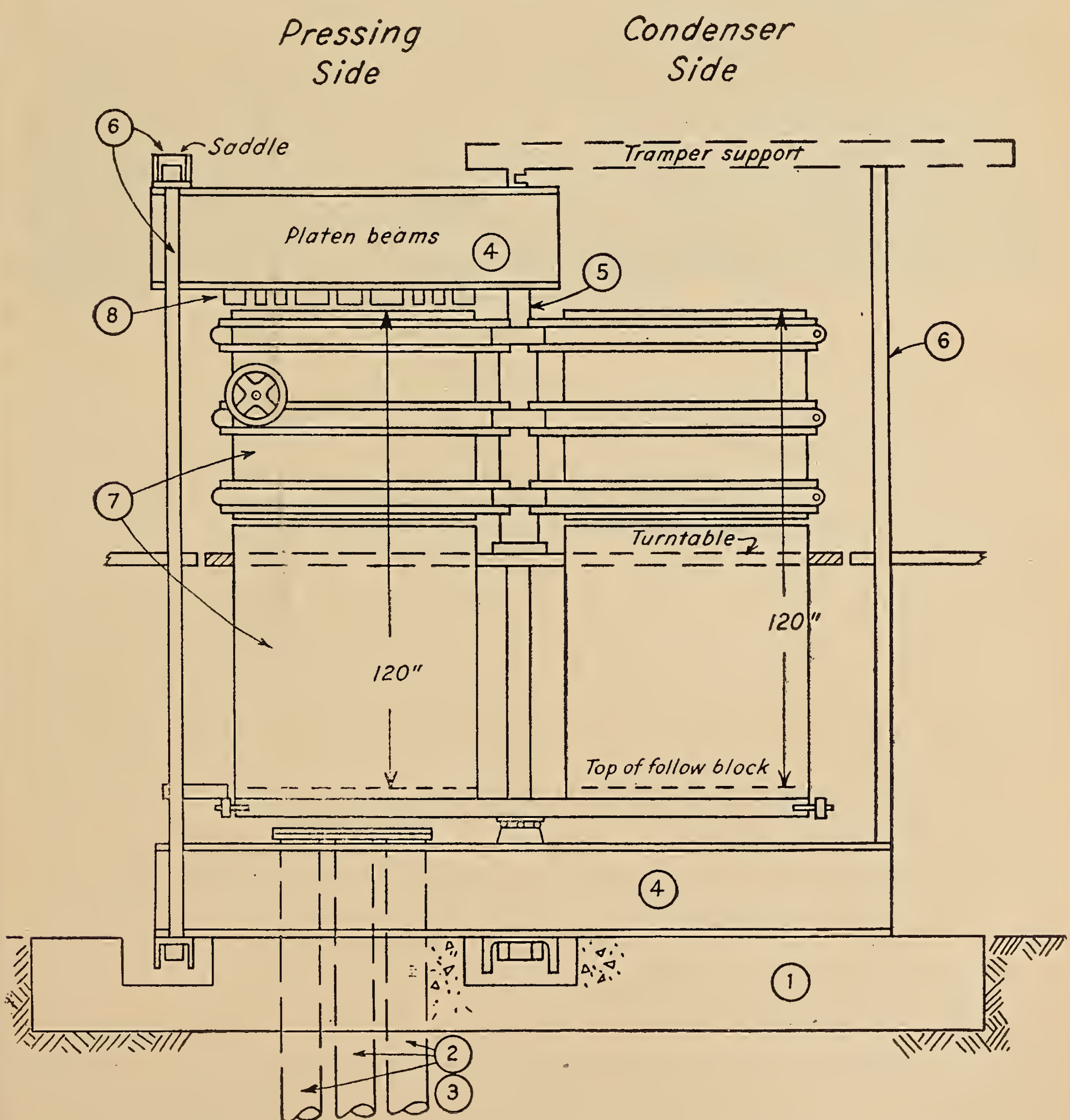


FIGURE 17.—Salient features of specifications for standard-density gin press of the up-packing type.

[10] A gin-press conversion similar to this Mississippi Delta gin-press conversion was made in a gin in the Mesilla Valley of New Mexico in 1943 for field observations of press performance with irrigated cotton that normally is drier and more resilient than rain-grown cotton. During the 1943 and 1944 seasons, more than 3,600 bales of cotton were pressed to standard density in this press equipped with 3 rams of 8½-inch diameter. Observations indicate that larger rams are needed to provide more acceptable bale density with dry cotton packed in bales weighing more than 500 pounds. The bale density was increased 60 percent with this press as compared with a low-density gin press operated under similar conditions, and the ram time in pressing a bale averaged 2.7 minutes for the former as compared with 1.5 minutes for the latter.

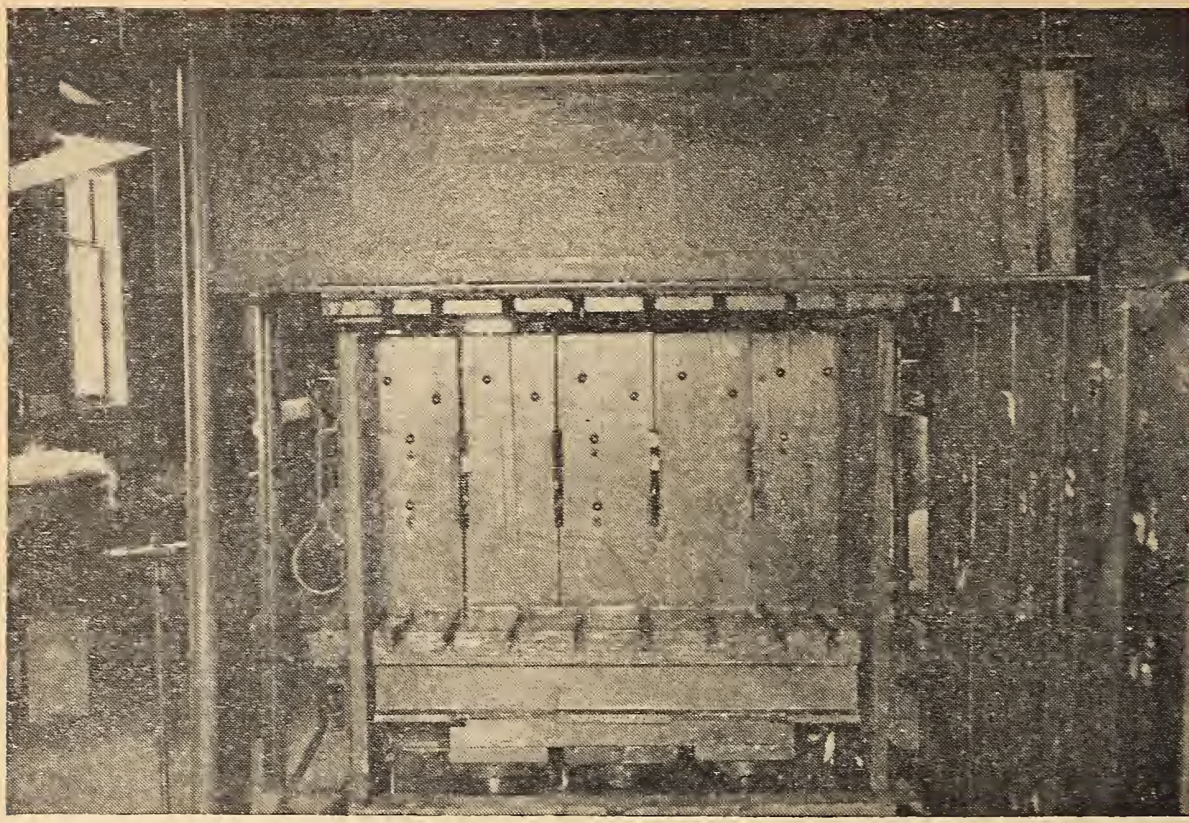


FIGURE 18.—Close-up view of the standard-density gin press used at a 4-80 gin plant in the Mississippi Delta.

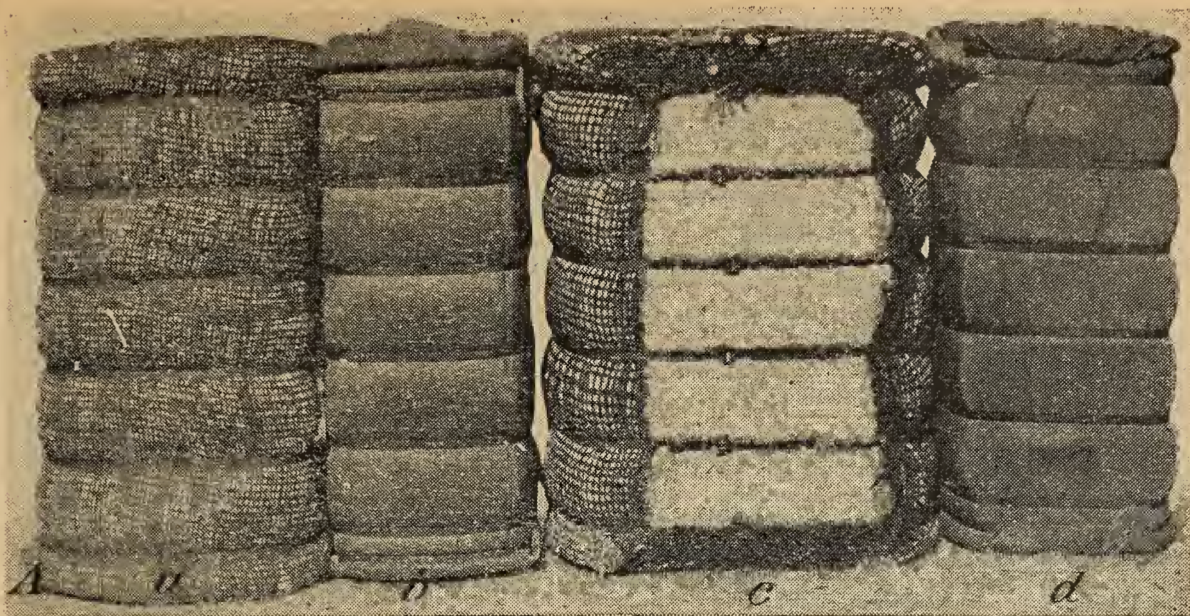
original condenser, tramper, cotton boxes below turntable, and the turntable structure were retained. Alteration of the tramper follower block, the condenser lint-slide lip, and the cut-off gate were made to permit the introduction of ginned lint into the narrowed press boxes. New sill and platen beams with heavier columns as well as a heavy center column were substituted in their entirety for the original lighter weight structural frame members of the press. Drop doors on the press boxes were converted to side-swinging doors with toggle latches. Press and cotton boxes were lined with smoothly finished, waxed oak liners to reduce the internal width of the press boxes to 20 inches. Hydraulic piping was provided for three 9½-inch diameter rams, and the original ram was removed.

The installation necessitated a somewhat wider and longer ram pit below ground level, so that the rams might be installed with block and tackle after the footings had been poured and the press sills set into position. Blocking up the turntable and press-box parts then permitted the removal of the center column and frame parts which were replaced by heavier ones.

In view of the difficulties encountered in adapting the condenser slide cut-off gate to the narrower box width of existing low-density presses, a factory-redesigned tramper lay-out would appear preferable in making a conversion of such presses to higher density presses.

SUITABILITY OF PACKAGE FROM STANDPOINT OF STORAGE, HANDLING, AND TRANSPORTATION

Standard-density gin-pressed bales are of such dimensions and weight that they will meet the requirements for most economical transportation to domestic mill centers as well as facilitate their handling in storage and in compression to high density for export.



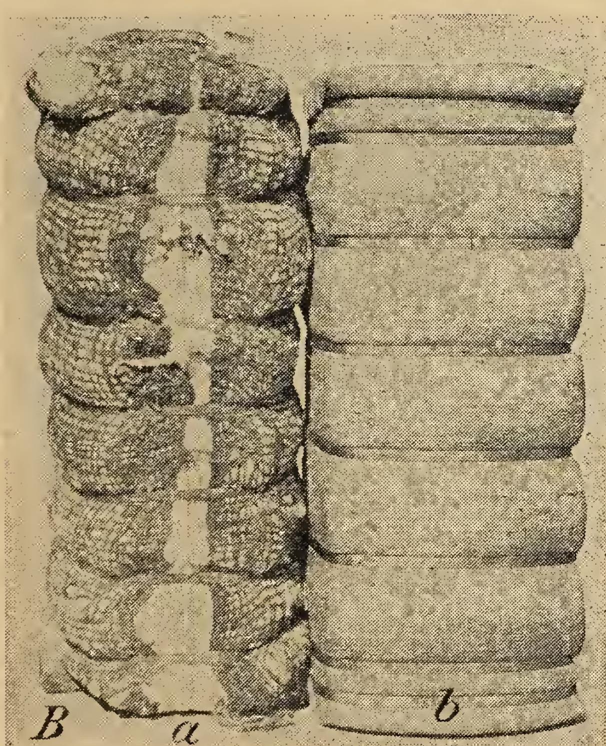


FIGURE 19.—*A*, Low-density gin bales, *a* and *c*, as compared with standard-density gin bales, *b* and *d*; *B*, standard-density compressed bale, *a*, as compared with standard-density gin bale, *b*.

A narrow 22-inch bale may be recompressed to high density with a minimum of lateral pressure from the side doors of high-density presses.

The average dimensions of standard-density gin bales are 56 inches in length, 22 inches in width, and 31 inches in thickness as compared with 56 inches in length, 31 inches in width, and 22 inches in thickness for bales pressed to standard density at compresses. But because of their more regular shape, standard-density gin bales occupy slightly less space in storage than a compressed bale of comparable density. The slightly "wedge" shape of the standard-density gin bales does not present any problem in stacking in storage if the bales are properly offset (fig. 20). Since the pressing operation with the standard-density gin press is of such nature that uniformly shaped bales are always produced, gin-pressed bales are more conveniently handled in shipment and storage than bales pressed at compresses to standard density from low-density gin bales.

FIGURE 20.—Left (*A* and *B*) standard-density compressed bales. Right (*A* and *B*) standard-density gin bales.

Frequently when fires occur in the cotton during the process of ginning, trouble is experienced from some of the burning cotton getting into the bales. Such "fire" bales create a special problem in storage because of the likelihood of continued burning in the interior even though not apparent on the exterior of the bales. Although gin fires have occurred at both of the gins where standard-density presses have been installed, bale fires have not been experienced in any instance. The assumption on the part of the ginners has been that the extra pressure applied in pressing to standard density has effectively extinguished the fires.

Irregularly shaped, or "rolling" bales, frequently turned out at the compress, cannot be handled in trucking and loading operations with as much ease as uniformly packed and shaped bales. Standard-density pressing at gins offers possibilities for producing bales of uniform density and shape. The flat heads of these bales provide a surface that permits storage on end without support. The bagging on these bales is securely held in place by the bale ties, whereas during the process of recompression of low-density bales, the bagging is not always properly arranged to cover the sides of the bale nor is the surplus bagging sewed together securely in order to cover the heads of the bale completely. These poorly covered recompressed bales present difficulties in handling and storage because of the loose tag ends of bagging.

Standard-density gin bales have a density, on the average, of about 22 to 25 pounds per cubic foot (table 6). A density of 22 pounds per cubic foot is generally required to meet loading requirements for minimum transportation rates. Available data indicate that standard-density compressed bales also average about 24 pounds per cubic foot in density. Apparently, this density is necessary in most instances to meet car-loading requirements, particularly in the case of irregularly shaped bales.

Table 6.—*Average dimensions and densities of standard-density compressed bales as compared with standard-density gin bales for different weight ranges*[1]

Bale weight (Pounds)	Standard-density compressed bales: Bales observed	Dimensions: Length	Dimensions: Width	Dimensions: Thickness	Density	Standard-density gin bales: Bales observed	Dimensions: Length	Dimensions: Width	Dimensions: Thickness	Density
	Number	*Inches*	*Inches*	*Inches*	*Pounds per cubic foot*	*Number*	*Inches*	*Inches*	*Inches*	*Pounds per cubic foot*
401–420	3	56.7	30.7	21.0	19.4	4	56.0	22.0	29.0	19.8
421–440	7	56.7	30.0	21.0	20.8	5	56.0	22.0	30.4	19.8
441–460	10	57.0	30.6	20.2	22.1	13	56.2	22.0	29.1	21.6
461–480	27	56.4	30.4	20.8	22.8	18	56.1	22.1	29.7	22.1
481–500	63	56.6	30.5	21.2	23.1	66	56.3	22.1	30.0	22.7
501–520	112	56.6	30.6	21.4	23.8	192	56.3	22.1	30.4	23.3
521–540	129	56.6	30.4	21.8	24.4	300	56.3	22.1	31.1	23.7
541–560	126	56.4	30.6	21.9	25.1	211	56.3	22.1	31.5	24.3
561–580	77	56.4	30.9	22.3	25.3	84	56.3	22.1	31.9	24.8
581–600	35	56.5	31.0	22.3	26.1	36	56.5	22.3	33.2	24.4
601–620	21	56.5	30.8	23.1	26.2	9	56.6	22.3	34.0	24.6
621–640	7	57.0	30.7	22.8	27.3	3	57.0	22.3	34.0	25.2
All weights	617	56.5	30.6	21.8	24.1	942	56.3	22.1	31.1	23.8

[1] Data based on compress weights and bale caliper measurements.

Car-loading tests of standard-density gin bales and standard-density compressed bales of comparable weight and shape have shown no significant difference with respect to meeting car-loading requirements when the two types of bales were loaded in a car of standard dimensions under the same handling conditions.

For the purpose of providing bales for a shipping and handling test, a crop lot of 100 bales of cotton grown in the Mississippi Delta was ginned and baled under comparable conditions at the United States Cotton Ginning Laboratory, with 50 bales pressed to standard density in the newly developed standard-density gin press and 50 bales pressed to low-density in a regular gin press and subsequently compressed to standard density at a compress establishment. The 100 bales were shipped in one box car to a southeastern mill for the manufacture of tire cord. Before shipping the bales, observations were made with respect to the condition of the bales and bagging. The standard-density gin bales were neater in appearance and had fewer bagging tears than the recompressed bales (fig. 21).

Observations were made on the condition of the bale coverings of the 100 bales upon their arrival at the mill, and of the physical condition of the lint during the various stages of processing in the mill. The standard-density gin bales reached the mill in relatively better condition and with better protection of their contents than the recompressed bales (table 7 and fig. 22). Only 12 of the standard-density gin bales showed bagging in poor to fair condition upon arrival at the mill, while the bagging of 39 of the recompressed bales was found to have sustained some damage.

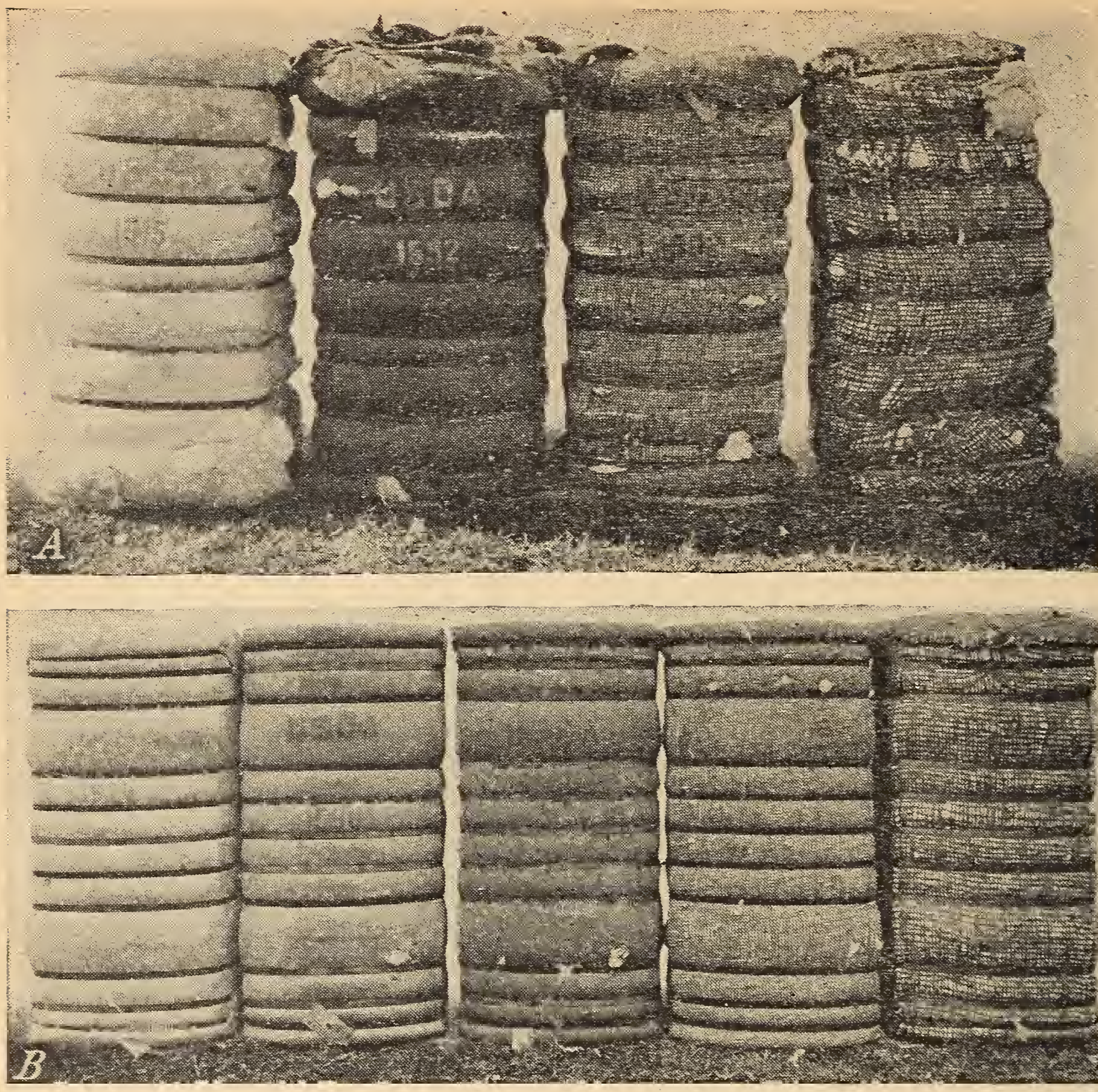


FIGURE 21.—Standard-density bales before leaving the warehouse for transportation to a consuming mill. *A*, Standard-density compressed bales; *B*, standard-density gin bales.

TABLE 7.—*Condition of specified kinds of bagging upon arrival of bales at cotton mill, by type of bale, season 1940-41*

Type of bale and kind of bagging	Number of bales	Condition of bagging: Good	Condition of bagging: Fair	Condition of bagging: Poor
Flat, recompressed to standard density:		*Bales*	*Bales*	*Bales*
Cotton	13	8	5	..
2-pound jute	13	3	9	1
1-pound jute	12	..	3	9
Jute twill	12	..	8	4
All kinds	50	11	25	14
Gin, standard-density:				
Cotton	11	11	..	..
2-pound jute	10	10	..	..
1-pound jute	5	1	4	..
Jute twill	7	7	..	..
Burlap	17	9	5	3
All kinds	50	38	9	3

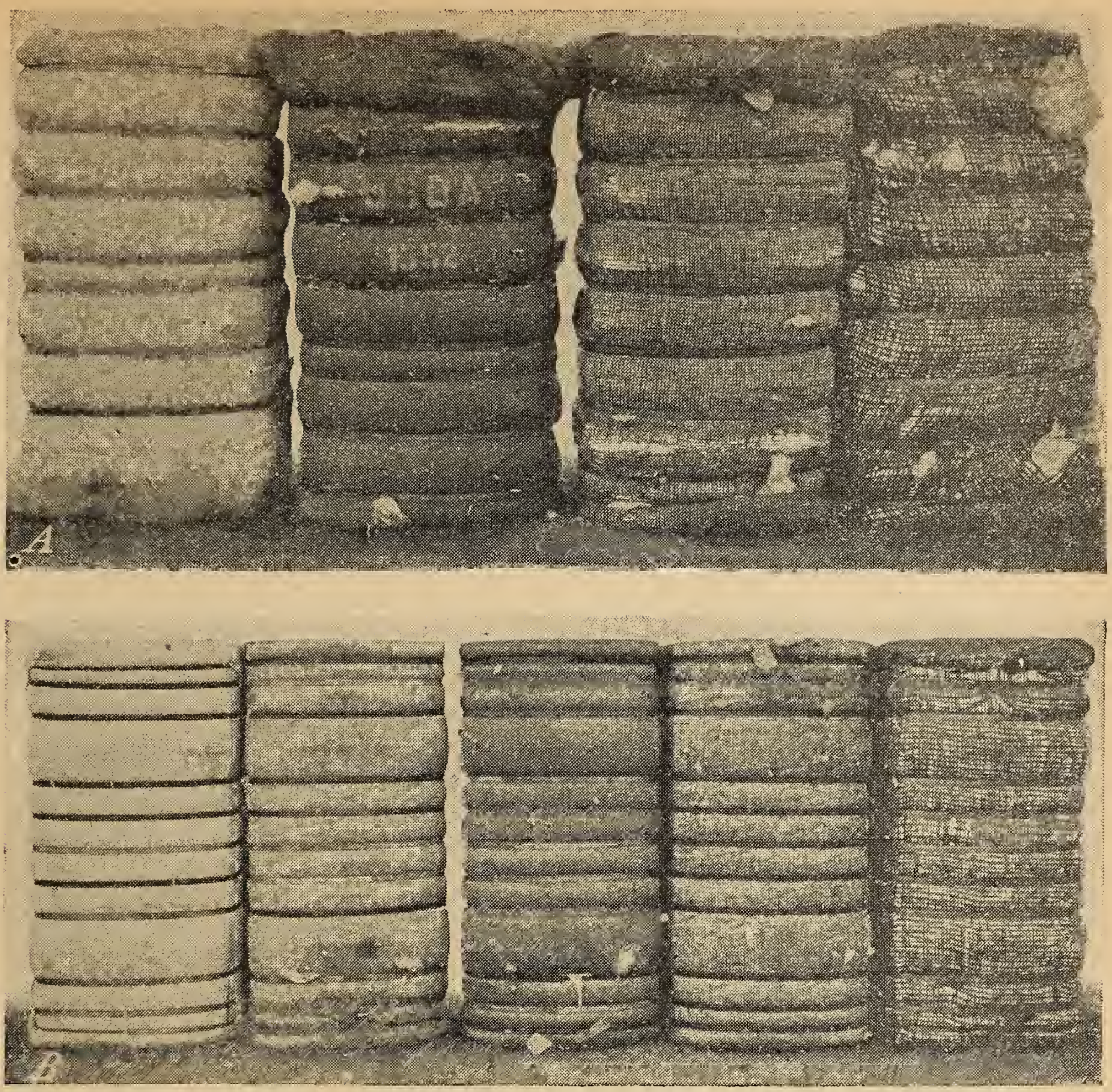


FIGURE 22.—The same bales as shown in figure 21, after arrival at a mill in South Carolina. *A*, Standard-density compressed bales; *B*, standard-density gin bales.

SUITABILITY OF PACKAGE FROM STANDPOINT OF OPENING AND PROCESSING AT MILLS

The standard-density gin bale, being narrower than the conventional standard-density compressed bale, has proved to have definite advantages from the standpoints of bale handling, opening, and processing at mills. Many mills have limited floor space around their openers or bale breakers. In such cases, the standard-density gin bales of approximately 22-inch width require appreciably less space than flat bales of 28-inch width or standard-density compressed bales of 30- to 31-inch width, and for a given floor space thereby permit the use of a larger number of bales in the mix.

The bale contents have sufficient resiliency to fluff out satisfactorily at mills when opened for processing. The density of the bales is sufficiently uniform to permit smooth running of the cotton in the preliminary processes of manufacture, and to provide uniform-sized yarns without more than normal changes in methods of operation of mill machinery. The bale is so pressed as to insure the preservation of the spinning value of its contents, and it permits

uniform raw-stock dyeing of the lint in the event the raw cotton is used in materials so treated before spinning.

Opening and Preliminary Processing.—In the processing at a commercial mill of a lot of 100 bales of even-running quality, 50 of which were standard-density gin bales and 50 standard-density compressed bales, it was observed that during the various stages of manufacturing the gin-pressed cotton, which showed superior layering of the lint, was processed with more ease than the recompressed cotton. Since gin-pressed cotton is not "killed," so to speak, in the pressing operation as happens to low-density bales when compressed, it has greater resiliency after the ties are removed from the bales for processing. This being so, gin-pressed cotton requires less fluffing during the mill-opening process to produce a uniform product than does cotton from compressed bales of comparable density.

Although standard-density gin pressing apparently improved the mill-running quality of the cotton as compared with recompression to standard density, the mill that processed this lot of cotton reported that there was no perceptible difference in the quality of the yarn and tire cord made from the cotton compressed by the two methods. Likewise, the manufacturing waste did not appear to be influenced by the different methods of pressing.

The 22-inch width gin-pressed bales may be re-pressed to high density for export without showing the objectionable hard-packed creases which are often found in bales that have been compressed to high density from low-density gin bales of 28-inch width, or from standard-density compressed bales of approximately 30 inches in width. The standard-density gin-pressed bales, being 22 inches in width, are not affected by lateral pressure in re-pressing to high density at compresses as are the wider bales.

In pressing 28-inch width bales to high density, lateral pressure by the side doors of the compress is required to reduce the width of the bales sufficiently to provide the density required. The layering of the bale contents is disturbed to such an extent that extra opening and fluffing are required to put the cotton in shape for smooth handling in preliminary processing in the mill. The creases are tightly matted masses of cotton which must be thoroughly fluffed out before processing (figs. 23 and 24).

Controlling Yarn Size.—Some cotton manufacturers object to the running of bales of different densities in the manufacture of yarn because the different densities of raw cotton result in different sizes in the stock, making it necessary to change the machine gears in order to maintain uniform size in the yarn. The differences in density of the raw cotton cause the fibers to draft differently in processing and result in unevenness in the stock. In mixes of low-density and standard-density cotton these difficulties are sometimes encountered even though the standard-density cotton is subjected to more extensive action of opening-room equipment. Generally, with higher-density cotton, more lines of feeders are required in processing the cotton than with low-density cotton. The rate of preliminary processing may be as much as 40 percent lower with compressed than with low-density gin-pressed cotton.

Laboratory tests have shown that cotton from standard-density gin bales, though having more resiliency than standard-density compressed cotton when opened at mills, can be run successfully along

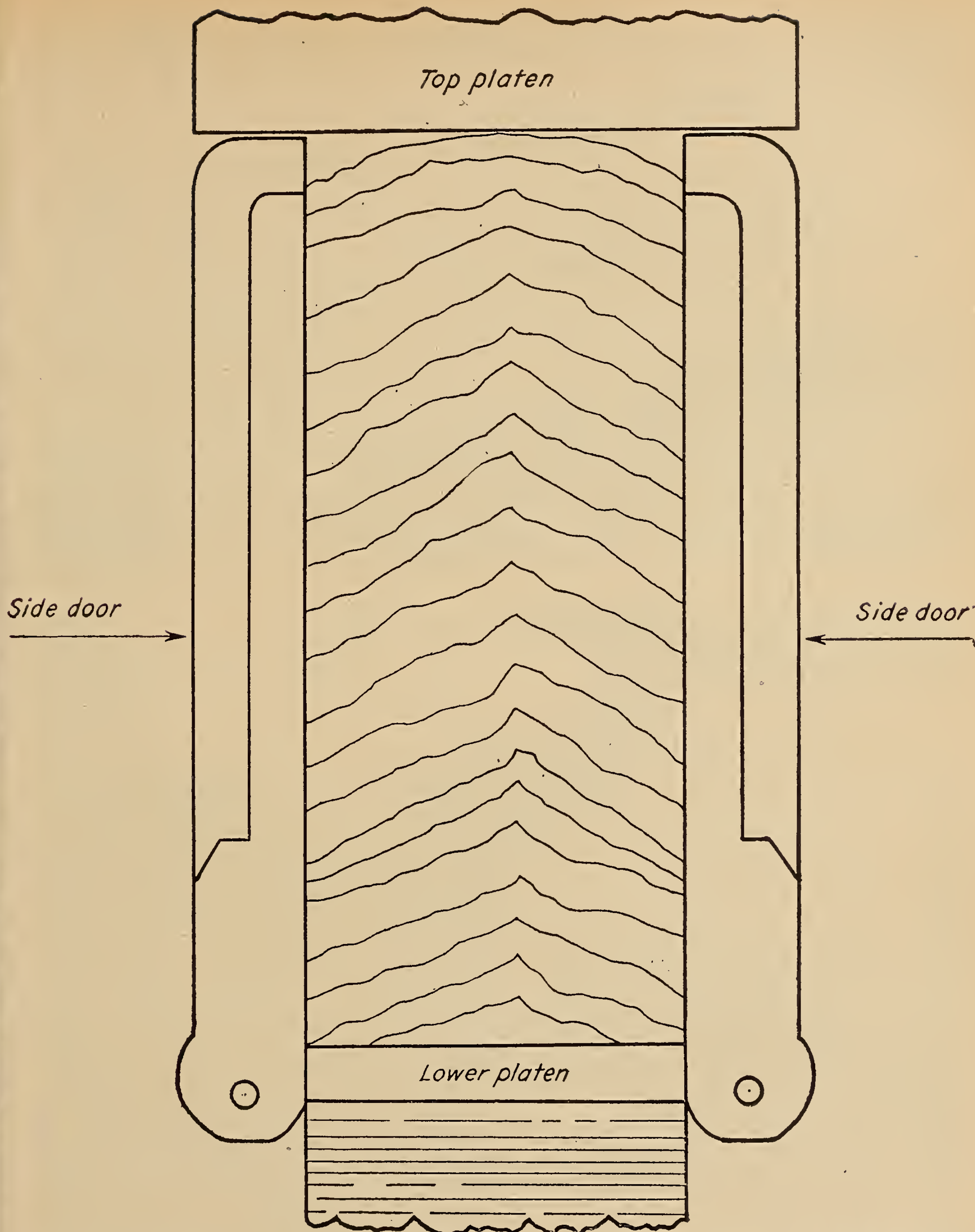


FIGURE 23.—Sketch of end view of bale in high-density press with side doors in vertical position after lateral pressure has been applied, but before vertical pressure is applied by raising of lower platen. This illustrates the inverted "V" shape of layers of cotton resulting from side compression.

with compressed cotton or handled in a mix with it without appreciably affecting yarn size. The tests indicated, however, that such cotton presents the same problem as cotton from standard-density compressed bales when mixed with cotton from low-density bales in a mill-run lot.

The laboratory tests consisted, first, of passing a quantity of the cotton, pressed to conventional low density, through the opener, breaker, and finisher pickers, card, and first- and second-drawing processes, following an average organization for the production of

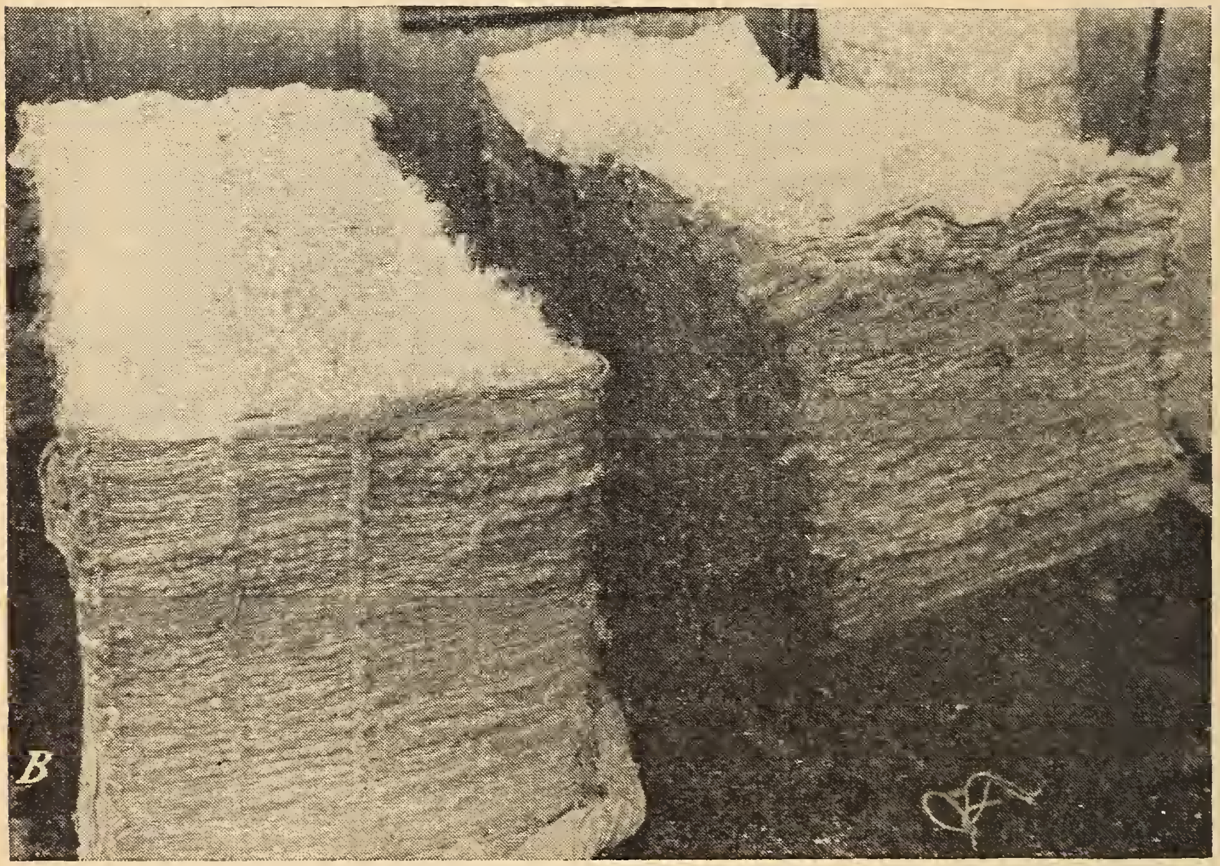


FIGURE 24.—High-density compressed bales which have been opened and a portion of top layers removed to show the effect of lateral pressure by the side doors of the compress on the layering of the cotton. *A*, This bale was packaged at the gin in a 27- by 54-inch standard-density gin press. *B*, These bales were packaged in a 20- by 54-inch standard-density gin press, before recompression to high density at the compress. The lateral pressure on the wider bale (*A*) caused the formation of the pronounced creases, but creases were not formed in the narrow width bales (*B*).

20s carded yarn. To determine the average sliver weight per yard, a large number of sizings were made at the card and at each of the two drawing processes. Following this, a quantity of cotton of the other bale types, including combinations or mixtures of the different

types, were processed on the same machines with exactly the same speeds, settings, and gearing, and sliver sizings made as in the case of the low-density bale lot.

A study of the average weight of the second-drawing slivers made from each of these lots showed that in general the second-drawing slivers from the higher density bales, including the compressed gin bales, were somewhat heavier than those from the low-density gin bales (table 8). In fact, they were enough heavier to require a change of at least one tooth in the draft change gear to bring them

TABLE 8.—*Counts of yarn spun from samples representing different bale densities and subjected to same drafts on roving and spinning frames*

Density of raw cotton	Weight of—			Yarn count [1]
	Card sliver	First-drawing sliver	Second-drawing sliver	
	Grains per yd.	*Grains per yd.*	*Grains per yd.*	*Number*
100-percent low-density gin-pressed cotton	48.83	50.05	49.74	20.00
100-percent standard-density gin-pressed cotton	51.15	52.49	52.61	18.91
100-percent standard-density compressed cotton	50.04	50.88	50.82	19.57
100-percent high-density compressed cotton	51.24	51.44	51.48	19.32
50-percent low-density and 50-percent standard-density gin-pressed cotton	50.70	50.38	50.55	19.68
50-percent low-density and 50-percent standard-density compressed cotton	48.42	49.36	49.22	20.21
50-percent low-density and 50-percent high-density compressed cotton	53.64	55.19	55.21	18.02
50-percent standard-density gin-pressed and 50-percent standard-density compressed cotton	51.29	50.82	50.73	19.61

[1] Using drafts of 4.00 on slubber, 5.00 on intermediate frame, 6.00 on fine frame, and 7.96 on spinning frame.

to the weight of the sliver from the low-density bales. Moreover, the slivers from the mixtures, with the exception of the lot composed of 50-percent low-density and 50-percent standard-density compressed cotton, were also enough heavier to require a change of at least one tooth in the gear. The heaviest sliver was produced from the mixture of low-density and high-density cotton. The sliver was about 5 grains per yard or 10 percent heavier than the sliver from the low-density gin bales. A comparison of the weights of the three types of sliver, namely, card and first and second drawings, indicated that practically all of the variation in the different lots was attributable to differences in picker lap weights.

In general, the differences in weight per yard of the card and drawing slivers are associated with differences in moisture content of the raw cotton from which they were processed. The raw cotton representing the high-density lots and the mixture containing a portion of compressed material had a higher percentage of moisture than the material from the low-density bales. Since all bales were ginned from the same cotton of uniform-moisture content, the low-density bales, being packed more loosely than the compressed bales, apparently dried out to a greater extent during handling and shipping. The combined influence of higher moisture content and bale density was reflected still further in coarser yarns produced at the same machine settings as compared with the yarn made from low-

density cotton. The results of the tests here reported, very definitely show that changes in draft gearing are necessary if cotton of one density is followed by cotton of appreciably different density.

Spinning Performance.—The effect of the degree of compression of raw cotton on its spinning quality has been a subject of interest to the American cotton industry for a great many years. Approximately 20 years ago, a preliminary study was made of this subject by the United States Department of Agriculture (7). Recently, more comprehensive tests have been conducted to ascertain more definitely the effect of type of bale and the density to which the cotton is pressed upon the spinning performance of the cotton.

Practical tests were planned and conducted to provide information on this subject. The first of these consisted of the packaging of cotton representing a wide range of moisture and foreign-matter content and staple length. The cotton was packaged as follows: (1) Low-density gin bales without recompression; (2) low-density gin bales compressed immediately to standard density; (3) low-density gin bales compressed to high density after storage for 1 month in a warehouse; (4) high-density gin-compressed bales; and (5) high-density round bales. At the time these tests were made, the standard-density gin press had not yet been developed.

Samples were taken from each bale included in this series of tests, immediately after ginning. These were classed for grade and staple length. Determinations of the moisture content of the lint were made in each instance. After a 4-month period of storage in a warehouse, the bales were again sampled, tested for moisture content, classed for grade and staple length, and subjected to laboratory spinning tests to provide data with respect to manufacturing waste, yarn strength, yarn appearance, and general processing performance.

After the 4-month period of storage, there were no significant changes in grade or staple length of the cotton for any of the bales in the test. The spinning tests indicated small but insignificant differences in spinning value of lint packaged in bales of the different types and densities. The cotton packaged in round bales, however, consistently yielded slightly more manufacturing waste and produced slightly weaker yarns than the other bales included in the test. There were no significant differences in this respect between the square bales of the various densities or methods of compression. Of special significance in connection with the study is the fact that the condition and quality of the lint were not affected by recompression of the bales to standard density immediately after ginning, as shown by comparison with bales pressed to the customary low density (table 9).

Evidently the heat generated within the round bale during compression causes some fiber deterioration which is responsible for the somewhat less satisfactory spinning quality. As compared with the negligible increases in the temperature of cotton within square gin bales during pressing (usually less than 2° F.), the round bales showed average temperature increases of 6° F. in the center of the bales, of 12° F. for 4 inches off center, and 53° F. for 8 inches off center in the bale (table 10). Fiber-strength tests showed average reductions in tensile strength of fibers of 900, 1,300, and 2,100 pounds, or 1 percent, 1.6 percent, and 2.5 percent for cotton from these re-

TABLE 9.—*Grade, staple length, and spinning performance of cotton as influenced by type and density of bale*

Item	Bale type and density				
	Rectangular bales				Round bales
	Low-density gin-pressed	Standard-density compressed[1]	High-density compressed[2]	High-density gin-pressed	High-density gin-pressed
Average density, pound per cubic foot	13	22	32	30	30
Classification:					
Grade	Middling+	Middling+	Middling+	Middling+	Middling+
Staple length, 3 inches	1³⁄₃₂	1³⁄₃₂	1³⁄₃₂	1³⁄₃₂	1³⁄₃₂
Manufacturing waste, percent	8.26	8.42	8.68	8.36	9.13
Yarn strength index [4]	97.4	96.2	96.7	97.7	95.2
Yarn appearance grade: [5]					
22s yarn	B	B	B	B	B—
60s yarn	C+	C+	C+	C+	C

[1] Compressed immediately after ginning.
[2] Compressed after 30 days' storage.
[3] Total picker and card waste.
[4] Average for three counts of yarn.
[5] Graded in accordance with the yarn appearance grades of the American Society for Testing Materials.

TABLE 10.—*Temperatures of cotton during pressing of round bales at gins and effect on fiber strength and length*

Bale type and position of cotton in bale	Temperature of cotton when pressed [1]	Tensile strength of fibers	Fiber length [2]
	° *F.*	*1,000 pound per square inch*	*Inches*
Low-density rectangular gin bale (central)	92	82.9	1.05
Round bale:			
Center	98	82.0	1.04
4 inches off center	104	81.6	1.04
8 inches off center	145	80.8	1.05

[1] Temperatures declined gradually and reached equilibrium with atmospheric temperature on ninth day after pressing.
[2] Upper half mean length by Fibrograph.

spective positions in round bales. The recompression of square bales to standard or high density had very little effect upon the internal temperature of the bales.

Upon the installation of a standard-density gin press at the United States Ginning Laboratory, a second series of tests was conducted in order to supplement the data available from the first series as reported in table 9, by providing data with respect to the effect of standard-density gin pressing on spinning performance. Cotton pressed to low density was again used as a control in this series. The test results, reported in table 11, indicate that pressing to standard density at the gin had no appreciable effect upon lint quality as determined by customary methods of classification, or upon spinning performance and yarn quality.

A third series of tests was designed not only to corroborate the results of the first and second series, but also to determine the safe upper limits in density to which cotton can be pressed at gins without affecting adversely the spinning performance of the fiber. The

cotton for this series of tests was packed in a pilot press providing 1 cubic foot of cotton per bale. The test series in this case consisted of one lot of dry cotton and one lot of damp cotton, the bales for each of which were pressed to densities of 22, 33, and 44 pounds per cubic foot at time of ginning.

TABLE 11.—*Comparative grade, staple length, and spinning performance of cotton pressed to low-density and standard-density at gins*

Item	Low density	Standard density
Bale density ... pounds per cubic foot..	13	22
Classification:		
Grade	Middling	Middling
Staple length ... inches..	1 5/32	1 5/32
Manufacturing waste [1] ... percent..	7.64	7.76
Yarn strength index [2]	103.1	104.5
Yarn appearance grade: [3]		
22s yarn	C	C+
60s yarn	C—	C—

[1] Total picker and card waste.
[2] Average for 3 counts of yarn.
[3] See table 9, footnote 5, p. 43.

After a 4-month period of storage, the cotton included in this series of tests was classed by the Appeal Board of Review Examiners of the Office of Marketing Services and was subjected to laboratory spinning tests. Classification grades averaged slightly lower for the cottons pressed to densities of 33 and 44 pounds than for the cotton pressed to a density of 22 pounds (table 12). Staple-length designations averaged the same for cottons of all three densities. Spinning-test results indicate a tendency for manufacturing waste to increase and yarn strength to decrease progressively with the density to which the cotton was pressed. The differences, however, were significant only in the case of the bales having a density of 44 pounds per cubic foot. These results indicate that cotton can be pressed to a density of 33 pounds per cubic foot without significantly impairing spinning quality.

TABLE 12.—*Grade, staple length, and manufacturing performance of cotton as affected by bale density*

Item	Bale density (pound per cubic foot)		
	22	33	44
Classification:			
Grade	Middling	Strict Low Middling	Strict Low Middling
Staple length ... inches..	1 1/8	1 1/8	1 1/8
Manufacturing performance:			
Manufacturing waste [1] ... percent..	9.36	9.52	10.03
Yarn-strength index [2]	101.3	100.7	99.5
Yarn-appearance grade: [3]			
22s	C—	C—	C—
60s	D+	D+	D

[1] Total picker and card waste.
[2] Average for 3 counts of yarn.
[3] See table 9, footnote 5, p. 43.

Raw-stock Dyeing.—A special series of tests was made which were designed to ascertain the effect of bale density on the raw-stock dyeing properties of cotton. Four lots of cotton of uniform-quality lint ginned from the same lot of seed cotton were packed in the following types of bales: (1) Low-density gin bales, (2) standard-density gin bales, (3) standard-density compressed bales, and (4) high-density compressed bales. The raw-stock dyeing tests of this cotton were made by a commercial mill. The test samples were dyed in a pressure vat customarily used by cotton mills for this process. After the lots were vat-dyed and subsequently dried in accordance with standard procedures, the material was examined for uniformity of dyeing. It was found that the lint cotton from the low-density gin bales dyed more uniformly than that from the other types of bales. The standard-density gin bales gave the next best results, followed in order by the standard-density compressed bales and the high-density compressed bales. The superiority of standard-density gin bales over both types of compressed bales is attributable, no doubt, to the greater resiliency of the lint in the gin-pressed bales which enabled it to take the dye more uniformly.

COMPARATIVE COSTS OF ALTERNATIVE METHODS OF PACKAGING COTTON

Initial Cost of Standard-Density Gin Press Equipment

Following the completion of the experimental work with the standard-density gin press, detailed specifications for the press were sent to manufacturers with a view of obtaining estimates of the price at which presses of this type could be offered to the ginning industry under normal conditions. The estimates averaged $5,500 complete with press boxes, rams, piping, and pump, but not including condenser and tramper. The usual prices charged by manufacturers for a low-density, all-steel gin pressing outfit, less condenser and tramper, average about $3,000. Since the press boxes of both types of presses are identical in length, standard condensers and trampers now employed with low-density gin presses are adaptable for use with standard-density gin presses following modification of the tramper foot and cut-off gate to fit the narrow 20-inch width box of the standard-density press.

Inasmuch as standard condensers and trampers used with low-density gin presses may also be employed with standard-density gin presses, there would be no difference in the cost of these units for the two types of presses. Therefore, the net additional cost of a new standard-density gin press over the cost of a new low-density press is estimated at about $2,500.

In some instances it might be feasible for ginners to find a market for their low-density pressing equipment when installing a higher-density system. The equipment might be sold as a complete unit or certain more serviceable parts might be salvaged and sold. It is estimated that the resale or salvage values of the low-density presses may vary from a few dollars to as much as $1,500, which amount when applied to the purchase price of a standard-density press would provide a corresponding reduction in the actual cash outlay for a new standard-density press.

Costs and Savings

The additional expense that a ginner would have to meet in equipping his plant with a standard-density press, therefore, would increase slightly the cost of providing packaging service to growers. The initial investment could be amortized over a period of years. In this case, the additional cost per bale would vary with the resale or salvage value of the low-density press, the ginning volume, and the number of years contemplated in the amortization plan. On a 20-year amortization basis, these increased fixed costs would range from about 5 cents per bale, with a ginning volume of 5,000 bales per season to 25 cents per bale with a ginning volume of 1,000 bales per season (table 13).

Table 13.—*Estimated costs of pressing cotton to standard density (22 to 25 pounds per cubic foot) at gins in comparison with costs of pressing to low density (11 to 15 pounds per cubic foot) at gins and subsequent compression to standard density at compresses*

Item	Cost of pressing at gins with annual volume (bales) of—								
	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
Low-density pressing at gins and compression to standard density at compresses:	*Cents per bale*	*Cents per bale*	*Cents per bale*	*Cents per bale*	*Cents per bale*	*Cents per bale*	*Cents per bale*	*Cents per bale*	*Cents per bale*
Gin fixed costs[1]	30.0	20.0	15.0	12.0	10.0	8.6	7.5	6.7	6.0
Gin operating costs[2]	3.4	3.3	3.1	3.0	2.9	2.8	2.8	2.8	2.8
Compression[3]	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
Total	103.4	93.3	88.1	85.0	82.9	81.4	80.3	79.5	78.8
Standard-density pressing at gins:									
Gin fixed costs[1]	55.0	36.7	27.5	22.0	18.3	15.7	13.8	12.2	11.0
Gin operating costs[2]	5.7	5.5	5.2	5.0	4.9	4.7	4.7	4.7	4.7
Total	60.7	42.2	32.7	27.0	23.2	20.4	18.5	16.9	15.7
Net saving from standard-density pressing at gins	42.7	51.1	55.4	58.0	59.7	61.0	61.8	62.6	63.1
Increased costs to ginners for standard-density pressing at gins	27.3	18.9	14.6	12.0	10.3	9.0	8.2	7.4	6.9

[1] The estimated cost of a new standard-density gin press is $5,500 and the cost of a new low-density gin press is $3,000. These prices include press pump and piping, but do not include cost of tramper and condenser which would be the same for presses of both types.
The life of each type of press is estimated at 20 years. The fixed cost figures were computed by allowing 5 percent interest on investment and 5 percent for depreciation.

[2] The average energy consumed per bale by the press pump and tramper in operating the standard-density gin press is 1.06 kilowatt-hours as compared with 0.60 kilowatt-hours for a low-density press. Power costs are based on rates of 4 cents per kilowatt-hour for the first 20,000 kilowatt-hours, 3.5 cents per kilowatt-hour for the next 10,000 kilowatt-hours and 2.5 cents per kilowatt-hour for all additional over 30,000 kilowatt-hours, with a 100 hp. electric-power unit consuming 20 kilowatt-hours per bale in driving the gin machinery and a low-density press outfit; and 20.46 kilowatt-hours per bale in driving the gin machinery and a standard-density gin press.
The operating costs here shown include 1.5 cents per bale to cover maintenance and repair for the standard-density gin press and 1 cent per bale for the low-density press.

[3] Average rate for standard-density compression, 1943-44 season.

The operating costs of a gin press are confined primarily to those for repair, maintenance, and power. No more labor is required for standard-density pressing than for low-density pressing. Maintenance and repair costs for a standard-density gin press are estimated to average about 1.5 cents per bale as compared with 1 cent per bale for a low-density gin press. On bales pressed with a commercial installation of a 20- by 54-inch standard-density gin press,

the average energy consumption of the motor driving the press pumps and tramper amounted to 1.06 kilowatt-hours while on bales pressed in a conventional low-density gin press, the energy consumption in operating the press pump and tramper averaged 0.60 kilowatt-hours. Approximately 33 percent of the increase in power consumed during operation of the standard-density gin press, compared with the power consumption of the low-density press, is due to the additional load imposed on the tramper in packing the lint in the smaller cotton box during late stages of packing.

For the low-density press, operating costs, including power, maintenance, and repair items, range from 2.8 cents with 5,000-bale volume gins to 3.4 cents per bale with 1,000-bale volume gins. For standard-density gin pressing, operating costs range from 4.7 cents per bale with a 5,000-bale volume to 5.7 cents per bale with a volume of 1,000 bales per season. Thus the increases in these costs with the standard-density gin press, as compared with the low-density gin press, range from 1.9 cents with a volume of 5,000 bales to 2.3 cents with a volume of 1,000 bales per season.

The total or over-all increase in cost to the ginner for packaging cotton in bales of standard density at the gin would vary from about 7 cents per bale for gins with an annual ginning volume of 5,000 bales per season to about 27 cents per bale for gins with a volume of only 1,000 bales per season (table 13). With a volume of 3,000 bales per season the total increased cost would be approximately 10 cents per bale, while with a volume of 2,000 bales, the extra cost would be about 15 cents per bale.

The possible economies associated with the development of a press to provide for the pressing of bales directly to standard density in one operation at gins as compared with low-density gin pressing and recompression to standard density at compresses, are apparent from the data presented in table 13. The net savings in costs of pressing a bale to standard density of 22 to 25 pounds per cubic foot at gins range from about 43 cents for a 1,000-bale ginning volume to 63 cents on a 5,000-bale volume.

At gins that have an annual volume of 1,500 bales, the total fixed and operating costs for packaging 100 bales of low-density cotton consisting of 48,000 pounds net lint cotton are estimated at $166.30 (table 14). With a recompression charge of 70 cents per bale,[11] the total costs of low-density gin packaging and recompressing of 100 bales would amount to about $236. The total costs for performing both operations at the gin with a 500-pound standard-density gin press is less than this amount by approximately $55. The costs for pressing and packaging high-density bales at gins to provide a shipment of 48,000 pounds of net lint cotton are approximately $200 for the high-density gin press designed for 400-pound bales, and about $125 for the round-bale gin press. Round-bale packaging is the most economical of all methods, principally because the cost of packaging material is only about one third that of packaging material required for square bales pressed in the other types of presses. An important point from a ginner's standpoint, however, is that power costs amount to about 19 cents per equivalent 500-pound bale with these round-bale presses as compared with only 4 cents per bale with the 54- by 20-inch box standard-density gin press. Also, as pre-

[11] Average rate for 1943-44 season.

TABLE 14.—*Comparative costs of packaging cotton at gins in bales of specified types*

Item	Gin-bale type: 500-pound bales: Low-density 27- by 54-inch press box	Gin-bale type: 500-pound bales: Standard-density 27- by 54-inch press box	Gin-bale type: 500-pound bales: Standard-density 20- by 54-inch press box	Gin-bale type: 400-pound high-density 20- by 40-inch press box	Gin-bale type: 250-pound high-density round bale
Bales observed, number	511	79	963	51	40
Average gross weight, pounds	515	521	533	410	261
Average bale density, pounds per cubic foot	13.5	22.8	23.8	30.0	30.0
Power consumption for pressing, kilowatt-hours per bale	.60	1.59	1.06	1.30	2.65
Per bale costs for pressing:					
Fixed costs,[1] cents	20.0	36.6	36.6	34.7	21.7
Operating costs,[2] cents	3.3	8.0	5.5	6.5	9.8
Total, cents	23.3	44.6	42.1	41.2	31.5
Packaging costs for 48,000 pounds of lint cotton, net weight:[3]					
Gin pressing	$23.30	$44.60	$42.10	$51.50	$63.00
Bagging and ties[4]	143.00	138.50	138.50	148.20	62.20
Total	$166.30	$183.10	$180.60	$199.70	$125.20

[1] For costs and depreciation rates for low-density and standard-density presses see footnote 1, table 13. Estimated costs of other presses are as follows: High-density gin press for 400-pound bales, $6,500 including condenser and tramper; round bale, $6,500, including condenser. Fixed cost figures based on 5 percent interest on investment in pressing equipment, 5 percent depreciation, and an annual ginning volume of 1,500 bales of 500 pounds each or the equipvalent.

[2] Power costs are based on rates of 4 cents per kilowatt-hour for the first 20,000 kilowatt-hours. 3.5 cents per kilowatt-hour for the next 10,000 kilowatt-hours, and 2.5 cents per kilowatt-hour for all additional over 30,000 kilowatt-hours, with a 100 hp. electric-power unit consuming 19.4 kilowatt-hours per 500-pound bale in driving gin machinery, in addition to the energy consumption per bale for pressing as shown for the respective presses.

Press maintenance and repair costs are estimated on a per-bale basis as follows: Low-density 1 cent, standard-density (27- by 54-inch press box) 2 cents; standard-density (20- by 50-inch press box) 1.5 cents; high-density 1.6 cents; round-bale 0.25 cents.

[3] Bale units required are as follows: Low-density, 100 bales; standard-density (both types), 100 bales; high-density, 125 bales; round, 200 bales.

[4] Costs of covering rectangular bales based on current price of 18 cents per linear yard of 45-inch, 2-pound jute bagging, and $1.75 per bundle of 30 ties, 11½ feet long.

Length of ties and number per bale are as follows: Low-density bales, 138 inches, 6 ties; standard-density bales, 114 inches, 8 ties; high-density bales, 100 inches, 11 ties.

Bagging dimensions are as follows: Low-density bales, 45 by 108 inches; standard-density bales, 50 by 90 inches; high-density bales, 45 by 72 inches (2 strips of bagging per bale in each instance).

Packaging costs for round bales are estimated as follows: Burlap 2 1/3 yards at 9 cents, 2 cut-bale heads at 3.3 cents each, and 2-ounce 10-ply cotton twine at 28 cents per pound.

viously stated, round bales as a general rule are not acceptable to cotton manufacturers.

As the length of the press box of the high-density gin press designed for 400-pound bales is substantially less than that of a conventional low-density press, presses of this type require the installation of a special condenser in place of the conventional-type condenser used with low-density presses. The replacement of a low-density gin press with a high-density gin press for 400-pound bales, would require some costly modifications of the tramper mechanism. Round-bale presses also require a special condenser, bringing their cost up to approximately that of the high-density gin press assembly. In view of the fact that existing condensers and trampers may be used with the standard-density gin press designed for 500-pound bales, presses of this type have an added advantage over other higher

density presses from the standpoint of initial costs of the press and auxiliary equipment. Moreover, in the case of round-bale press installations, a square-bale low-density press is generally required as an alternate method of packaging for cotton destined to markets that will not accept round bales.

Since the press developed for standard-density gin compression provides a 500-pound bale as compared with the 400-pound and 250-pound bale provided by the high-density gin bale and the round-bale presses, respectively, there would be fewer bale units to mark, sample, class, and handle in warehousing and marketing channels, as well as fewer records to be kept. Service charges for these operations are made on a bale-unit basis; therefore, the 500-pound bale has a five to four advantage over the 400-pound bale, and a two to one advantage over the round-bale press from the standpoint of these items of cost in the physical handling of the cotton in marketing channels.

POSSIBILITIES FOR CONVERSION OF LOW-DENSITY GIN PRESSES FOR HIGHER-DENSITY PACKAGING

The ginning industry of the United States is now so organized that the annual volume of ginning of many plants is too small to justify the investment necessary to install modern ginning equipment (table 15). Because of this, a substantial proportion of existing gin plants would find the per-bale cost of installing a standard-density press prohibitive. On the other hand, more than 2,000 gins have an annual ginning volume of more than 1,500 bales per season, which would easily justify the installation of new standard-density presses to replace existing presses. Gins in this category now gin more than half of the United States cotton crop (table 16).

Although it is believed that in general more satisfactory results will be obtained by the installation of new standard-density gin presses, the conversion of existing low-density gin press equipment to standard-density pressing would be economically feasible in a great many instances where gins are equipped with "iron-bound" or all-steel presses of the following types: Up-packing, 2-story hydraulic; up-packing, 2-story screw; up-packing, 1-story hydraulic; or down-packing, 1-story hydraulic.

Up-packing, 2-story hydraulic presses are suitable for conversion by proper strengthening of the frame and box parts, together with the addition of two rams to provide a triple ram assembly having a 90-inch stroke, as given in the specifications previously outlined. If the demand were sufficient, factory-built parts for conversion of these presses would no doubt be made available at prices within the reach of the gin owner. The conversion of such presses has already proved feasible. Engineering methods of frame and press-assembly strengthening are not limited to those employed by the United States Cotton Ginning Laboratory.

Up-packing, 2-story screw presses, of which there are relatively few in large-volume gins, would require the substitution of 90-inch

TABLE 15.—*Number of cotton gins in specified volume of ginning groups, by States, season 1941-42*

Bales ginned per season	Ala.	Ariz.	Ark.	Calif.	Fla.	Ga.	Ill.	Ky.	La.	Miss.	Mo.	N. Mex.	N. C.	Okla.	S. C.	Tenn.	Tex.	Va.	U. S.	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Cumulative percent*
250 and under	252	2	147	2	16	313	....	1	183	175	....	2	128	35	295	21	618	23	2,213	19.8
251 to 500	226	2	168	2	8	312	....	1	167	223	2	2	174	94	193	40	647	17	2,278	40.3
501 to 750	180	3	150	....	5	215	....	2	97	195	4	2	190	108	120	42	452	7	1,772	56.2
751 to 1,000	125	1	117	1	1	125	....	....	41	153	6	1	98	124	80	60	314	2	1,249	67.4
1,001 to 1,250	97	3	100	3	1	74	1	2	30	117	15	1	77	97	48	64	192	6	928	75.7
1,251 to 1,500	69	3	88	2	2	36	1	1	25	80	9	1	44	64	26	42	128	....	621	81.3
1,501 to 1,750	48	2	68	4	....	26	....	....	13	67	17	5	33	45	10	41	115	....	494	85.7
1,751 to 2,000	25	4	64	3	....	18	....	....	10	67	16	4	23	23	11	25	73	....	366	89.0
2,001 to 2,250	17	3	45	8	....	5	....	1	6	44	23	4	8	21	2	25	65	1	278	91.5
2,251 to 2,500	12	2	26	2	....	3	....	1	1	39	20	4	3	8	3	13	56	....	193	93.2
2,501 to 2,750	4	5	25	3	....	3	....	....	....	31	8	....	5	10	4	12	49	....	159	94.6
2,751 to 3,000	....	1	29	4	1	....	....	....	....	18	12	3	1	4	2	10	31	....	116	95.7
3,001 to 3,250	2	1	14	5	....	2	1	1	1	8	15	1	1	8	1	2	32	....	95	96.5
3,251 to 3,500	1	3	12	5	....	....	....	....	....	12	8	2	....	4	....	5	24	....	76	97.2
3,501 to 3,750	2	3	11	5	....	1	....	....	1	11	12	1	....	2	1	5	15	....	70	97.8
3,751 to 4,000	....	....	9	12	....	....	....	1	....	5	5	2	....	....	....	4	9	....	47	98.3
4,001 to 5,000	4	4	19	22	....	....	....	....	....	17	12	5	....	2	....	5	30	....	120	99.3
5,001 and over	....	13	13	22	....	....	....	....	....	5	5	1	....	1	....	2	11	....	73	100.0
Total active gins	1,064	55	1,105	105	34	1,133	3	11	575	1,267	189	41	785	650	796	418	2,861	56	11,148	100.0

Data adapted from U. S. Bureau of the Census reports.

TABLE 16.—*Cotton gins having annual volume of ginning of more than 1,500 bales and cotton handled by such gins, by States and regions, season 1941-42*

State and region	Gins with annual volume over 1,500 bales		Cotton ginned by gins having annual volume over 1,500 bales	
	Number	*Percent of total gins*	*Bales*	*Percent of total*
Alabama	115	10.8	232,316	30.0
Florida	1	3.0	2,010	13.5
Georgia	58	5.1	104,844	16.4
North Carolina	74	9.4	136,103	23.9
South Carolina	34	4.3	64,098	15.7
Virginia	1	1.8	1,901	7.9
Southeastern region	283	7.3	541,272	22.3
Arkansas	335	30.3	870,214	63.0
Illinois	1	33.3	2,974	54.3
Kentucky	4	36.4	11,743	68.6
Louisiana	32	5.6	60,376	19.4
Mississippi	324	25.6	784,683	56.6
Missouri	153	81.0	433,269	92.0
Tennessee	149	35.6	347,996	60.6
Mid-south region	998	28.0	2,511,255	60.6
Oklahoma	128	19.7	279,553	40.4
Texas	510	17.8	1,288,577	50.4
Southwestern region	638	18.2	1,568,130	48.2
Arizona	41	74.5	167,087	93.7
California	95	90.5	387,569	98.0
New Mexico	32	78.0	90,434	94.1
Far western region	168	83.6	645,090	96.3
United States	2,087	18.7	5,265,747	50.2

Data adapted from U. S. Bureau of the Census reports.

stroke triple-hydraulic rams and casings for the screw, but other elements of conversion would be the same as for hydraulic 2-story existing presses.

Single-story up-packing all-steel presses are relatively few in number, and their conversion would be the same as for 2-story presses, except that the depth of the cotton box would have to be increased by adding to the top of the box.

Engineering studies are being made of down-packing 1-story hydraulic presses to ascertain the feasibility of converting them to standard-density presses. Apparently, however, presses of this type will present certain complications in connection with their conversion or redesign to provide standard-density bale packaging. The principal difficulties in the conversion of the down-packing 1-story hydraulic presses are the necessity for providing suitable tramper and cotton-box dog mechanisms, and an increase in length of ram stroke for operation with the shallower cotton boxes of this type of gin press.

BALE COVERING MATERIALS FOR STANDARD-DENSITY GIN BALES

Any of the customary types of bagging employed at gins may be used on the standard-density gin bales. The closely woven bagging fabrics, however, are more desirable, as they provide better protection of the bale contents, permit greater security in sewing together the bagging on the heads of the bale, as well as provide better bale appearance. It is important that the bagging on the heads of the bales be securely sewed to provide neatness and adequate protection to the cotton.

The bagging dimensions should be 50 by 90 inches in order to allow for a complete coverage of the bale contents on all sides (fig. 19). The smaller dimensions of the standard-density gin bale permit a complete coverage of the bale with a reduction of 5 square feet in the surface area of bagging required, as compared with the low-density gin bale. The time available for packaging and tying individual bales at the gin permits a more thorough job of covering the bale than is usually possible at compresses.

The ordinary methods of tying low-density gin bales with 1½-pound flat ties and Arrow buckles, weighing 45 pounds per bundle of 30 ties and buckles, were found to be unsatisfactory when applied to standard-density gin bales. The ties often slipped slightly at the buckle causing expansion of the bale and consequent loss in density, or were sheared at the looped portion coupled to the buckle.

Laboratory strain tests of the 1½-pound bale tie and the Arrow buckles indicated the strength of each to be adequate for tying the gin-compressed bale if the element of shearing and slippage of the tie could be prevented. The tendency of the tie to shear at the buckle was eliminated, and slippage or creeping greatly reduced, by bending the ends of the tie back upon itself to provide double thickness of the metal at the loops formed in the tie for coupling to the buckle (fig. 20).

Eight 1½-pound ties, 114 inches long in combination with Arrow buckles, have been found to be satisfactory in the Mississippi Delta for use in tying standard-density gin bales when the ties are folded for double thickness at each end to prevent shearing and slippage at the buckles. This method of applying ties on a standard-density gin bale provides a tied-out bale density which more closely approximates that attained before release of the bale from the press (fig. 25). The practice of folding the ties to provide double thickness of metal for coupling the ties to the buckles permits the use of 1½-pound ties in place of 2-pound or heavier ties, and the desired tied-out bale density is attained with less energy consumption by a reduction of ram travel in pressing the bale with greater separation between the press platens.

In those areas where the lint cotton is unusually dry at the time of ginning, it has been found advisable to use 11 ties in order to retain the bale density desired.

In addition to the regular cotton bale ties, various types and sizes of flat ties and high carbon steel-wire ties, used commercially for packaging various types of baled material, were tested for service with the standard-density gin bale. These either proved to be un-

FIGURE 25.—Vertical section of buckle, illustrating method of tying standard-density gin bale with 1½-pound tie and Arrow buckle.

satisfactory in service or too costly in materials and methods of application. However, an adjustable wire tie of No. 9 gage cold drawn-steel wire, developed by the United States Cotton Ginning Laboratory, could be used in place of flat ties for tying the standard-density gin bale (fig. 26). These wire ties, approximately 5/32-inch in diameter, necessitate the use of 11 ties with each bale to restrict the degree of bulge normally occurring between adjacent ties after the bale is removed from the press box. Compared with the weight of eight 114-inch, 1½-pound flat ties used in tying the standard-density gin bale, the use of eleven No. 9 gage wire ties would effect a reduction in weight of approximately 40 percent of the steel required for manufacture of the flat cotton-bale ties and Arrow buckles.

The eight shorter-length flat ties used in conjunction with the smaller-size bagging patterns for covering standard-density gin bales, permit the maintenance of tare weights customary in packaging low-density gin bales (table 17).

As long as the present system of sampling cotton bales prevails, the spacing of the tie channels in the gin-press platens should be arranged to permit sufficient space between the ties for cutting samples from the completed bales. The spacing recommended between the tie channels of the press platens for the eight flat ties are as follows: 2¼, 3½, 3½, 9, 6, 9, 3½, 3½, 2¼ inches. The tie channel spacing of the press platens for the 11 wire ties is 1¼, 3, 3, 3, 7½, 3, 3, 7½, 3, 3, 3, 1¼ inches (fig. 27).

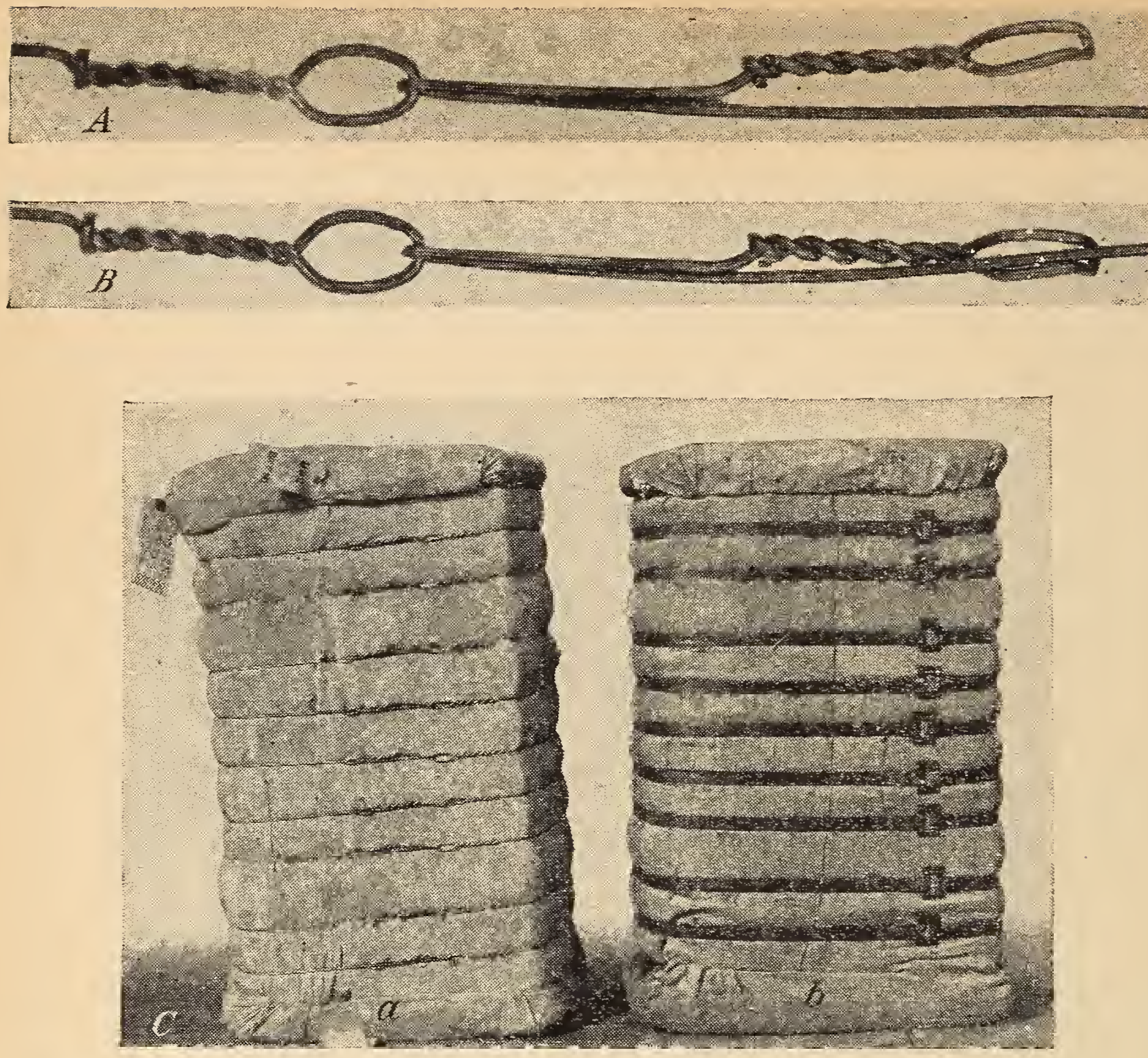


FIGURE 26.—One-piece, adjustable-length, cotton bale wire tie. *A*, Wire tie. illustrating details of construction and method of fastening: *B*, wire tie in locked position; *C*, wire ties *(a)* on gin-compressed bale in comparison with flat-steel ties *(b)*. Relative weights: 11 wire ties 4.9 pounds; 11 flat-steel ties 11.6 pounds.

TABLE 17.—*Comparison of dimensions and weights of bagging and ties for low-density with standard-density gin bales of cotton*

Type of bale	Size of each strip of bagging	Weight of bagging per bale		Ties			Total tare	
		Cotton	2-pound jute	Number	Length	Weight	Cotton-covered bale	2-pound jute-covered bale
	Inches	*Pounds*	*Pounds*		*Inches*	*Pounds*	*Pounds*	*Pounds*
Low-density gin bale	45 by 108	4.5	12.0	6	138	9.0	13.5	21.0
20- by 54-inch standard-density gin bale	50 by 90	4.2	11.1	8	114	9.9	14.1	21.0

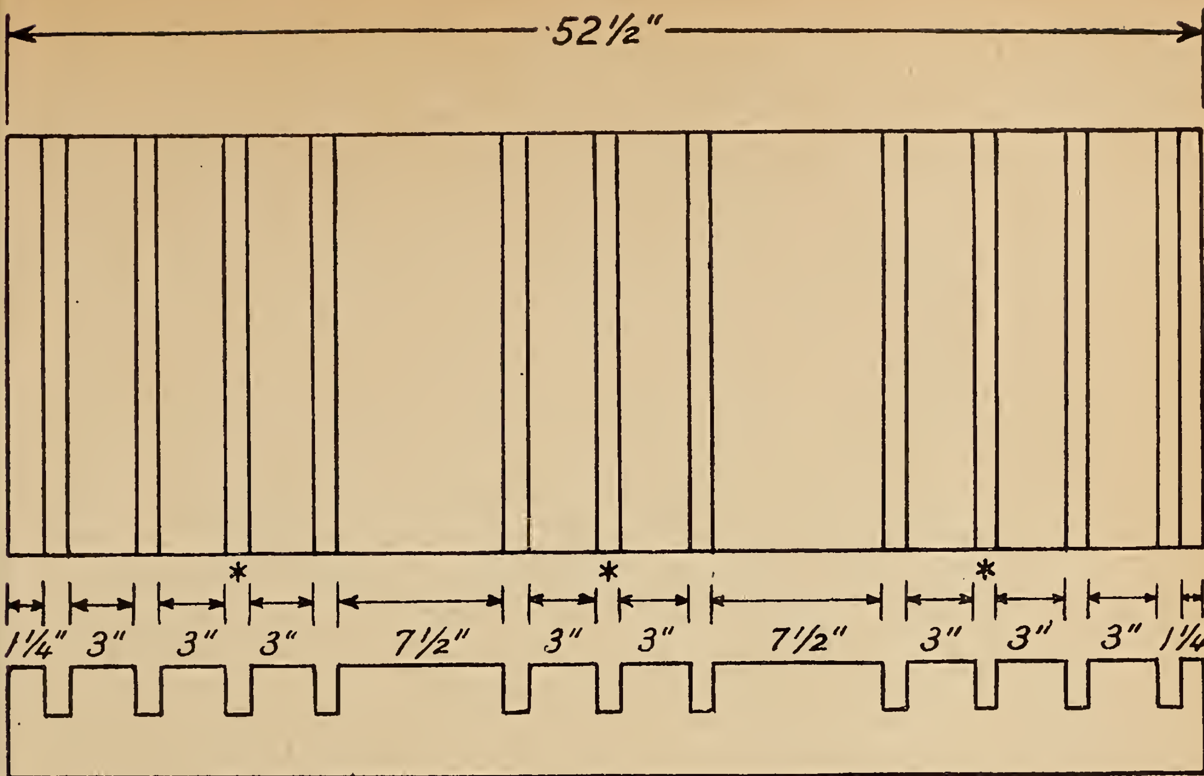


FIGURE 27.—Tie channel spacings recommended for standard-density gin press. The third from each end, and center channels, are not used if eight flat ties are used on the bales.

PROBABLE EFFECT OF GIN COMPRESSION ON COTTON-MARKETING SYSTEM

The installation of gin presses capable of producing bales of standard density (22 pounds per cubic ft.) would eliminate the need for the recompression of the bales for domestic shipment. Carloadings required for minimum rail rates for shipments destined to consuming centers in the United States and Canada can be obtained with such bales. Cotton destined for overseas shipment would require recompression to high density in order to obtain minimum ocean freight rates.

Under the present system of handling and marketing cotton, the low-density gin bales from country markets usually are assembled in concentration centers that are strategically located with respect to areas of cotton production, cotton ports, or cotton-mill centers, and at which transit privileges are available. At these centers, various services such as sampling, weighing, marking, and storage are performed. It has been customary for concerns providing these services at the concentration centers to install compress facilities for the recompression of gin bales to the densities required for minimum transportation rates.

Because of the miscellany of cotton varieties planted in most producing areas and the consequent mixture of qualities shipped from any one point, centralized assembly has usually been considered necessary in order to permit sorting into lots of even-running quality as required by mills. But recent trends in connection with the production, ginning, sampling, and processing of cotton appear likely to affect very materially the handling and marketing of this commodity.

Cotton breeders have made remarkable progress in developing improved varieties and strains of cotton that not only provide high yields but also superior spinning performance. Individual producers are recognizing the advantages of growing these improved varieties and strains and of affiliating with others in standardizing the production of a single variety in their community, thereby making possible the maintenance of the purity of planting-seed stocks and the establishment of the reputation of the producing area for a superior product.

For many years cotton manufacturers and marketing agencies have attempted to deal with quality in raw cotton primarily on the basis of grade and staple length. The factors determining grade have provided a fairly reliable index of manufacturing waste as well as of the extent of fiber deterioration. Staple length has provided a fairly good index of the use to which a given lot of cotton is adapted, the yarn strength to be expected, and the machinery organization required to process it. It has long been recognized, however, that factors of quality other than grade and staple length are also important from the standpoint of spinning performance. These factors have been rather loosely referred to under the inclusive term "character" and have been somewhat elusive from the standpoint of objective evaluation in commercial practice.

Research of recent years has not only developed laboratory methods for the measurement of such physical properties of cotton fibers as tensile strength, fineness, length uniformity, and maturity, but has indicated the relationships of these fiber properties to processing performance and to yarn and fabric quality. The fact that various fiber types are inherent characteristics of specific varieties and growths of cotton has also been established. As manufacturers are becoming acquainted with the fiber characteristics of specific varieties and growths of cotton and their adaptability to specific uses, they are realizing that character, the "third dimension" of cotton quality, can be dealt with most effectively in terms of variety and growth and that it is highly advantageous to include this factor along with grade and staple length in specifying their raw-cotton requirements.

The standardization of the production of the improved varieties of cotton on an area basis will facilitate mill buying of specific varieties and will make possible the shipment of such cotton in carload lots direct from gin points in those cases where gins are equipped to package the cotton in bales of sufficient density to attain carloadings required for minimum rail transportation rates. Whether this development will result in direct mill buying in producing areas and the shipment of the cotton direct from gin points to mills, will depend, no doubt, upon the readiness with which marketing agencies and the management of compress and warehouse facilities adapt their policies and procedures to the changed conditions.

In any event, there will continue to be a need for many of the services other than the compression of the bales, that are required incident to the marketing of cotton, and that are now performed by the compress and warehouse industry. Whether these services will continue to be performed by existing facilities at the large concentration centers, by facilities developed at gin points, or by the

development of additional facilities in cotton-mill centers, will depend primarily upon economic considerations but will, no doubt, be influenced by the foresight of the management of existing facilities as reflected in their policies with respect to rates and services. For the most part, these facilities represent a high degree of efficiency and economy in the storage and handling of cotton. This should give these facilities a definite advantage in competing for the performance of such services, provided sound policies with respect to rates and services are adopted.

At present the majority of the companies operating cotton compress and warehouse facilities in the United States make a delivery charge for bales not compressed by them. That is to say, when cotton either uncompressed or compressed is placed in storage in one of these facilities and is later withdrawn from storage without having the bales compressed, the owner is required to pay in addition to accrued charges for storage and other services performed, a charge for delivering from the warehouse. This charge is not made when the bales are compressed in the facility plant. Such delivery charges in many cases are equal to or approximately equal to the charge for compression.

Obviously, this system of charges would tend to offset the initial advantage of compression at the gin, provided the gin-compressed bales were to be stored in cotton compress or warehouse facilities. Since a period of storage normally is required for the proper protection of the cotton between the time the bales are ginned and the time they are shipped to consuming mills, the adoption of gin compression in areas where this system of charges prevails, would encourage the development of storage facilities either at gin points or in cotton-mill centers. Under conditions previously prevailing, neither of these alternatives would have been feasible because of the need for concentrating the cotton in large quantities in order to permit assembling lots of even-running quality to meet the requirements of mills, and because recompression of gin bales was required in order to obtain minimum rail-transportation rates. The recent trend toward single-variety cotton-production areas is making possible the assembling of lots of even-running quality at gin points. This development, combined with the adoption of standard-density compression of the bales at gins, would make possible the bypassing of the central concentration points in the marketing of cotton.

The development of adequate storage facilities at gin points would make possible the storage of the cotton as ginned and until ready for shipment to mill centers. The bales of smaller dimensions resulting from gin compression, would contribute to the economy of such storage. Unless adequate fire-protective facilities were available at such points, however, rates for insurance on the stored cotton might be somewhat higher than at modern facilities located in the large concentration centers.

Present facilities for the storage of cotton in domestic mill centers are not adequate for storing more than a rather minor part of the annual supply of American cotton. Although storage in such centers would not necessarily be subject to the handicap of high insurance rates, the market outlets for cotton thus stored might be more restricted than for cotton stored at present concentration points or at local gin points because many of the mill centers are out of the line

of movement to ports as well as to other domestic mill centers.

It is not improbable, however, that there will be a tendency toward the development of storage facilities for cotton both at gin points and in cotton-mill centers. This will be necessary if full advantage to spinners is to be realized from standardized production of cotton by single-variety areas, unless in the meantime the marketing system provides means for safeguarding the identity of such cotton by variety and growth. Such a shift in practices with respect to the storage of cotton would be possible by the installation at gins of presses that will provide bales of sufficient density for obtaining minimum transportation rates. The tendency in this direction would, no doubt, be accelerated by any attempt on the part of the management of existing compress and warehouse facilities to discriminate in their rates and services against gin-compressed bales handled through their facilities.

Changes in the place of storage of cotton, already referred to, would not necessarily mean any change in the marketing channels. Whether the marketing of cotton will continue through existing channels will, no doubt, depend primarily upon the extent to which cotton merchants adjust their procedures to changing conditions in the production, packaging, sampling, and utilization of this commodity.

Equipment has been developed for the automatic mechanical sampling of bales during the process of ginning. The use of this equipment will make unnecessary the cutting of bales for samples and will obviate the need for the application of patches. Gins that install standard-density presses will probably find it advantageous also to install such sampling equipment.

Cotton manufacturers who now buy their cotton direct from producing areas are able to obtain supplies of the improved varieties of cotton without the loss of its identity, which otherwise usually occurs under the customary system of concentration in the large concentration centers. Obviously, the packaging of cotton in standard-density bales at gins would facilitate such direct buying by mills. Indications are, however, that the more progressive cotton merchants will adjust their methods to the changes now being made, in which case the impact of the adoption of gin compression on the existing marketing system is likely to be minimized.

If American cotton is to retain its markets in competition with synthetic fibers as well as with foreign cottons, every possibility of reducing costs of production and marketing must be utilized. The adoption of gin compression would make possible a substantial reduction in the over-all cost of marketing cottons. Marketing agencies that take advantage of this reduction will, quite obviously, strengthen their competitive position in relation to those agencies that fail to adjust their procedures of handling cotton to take full advantage of the improved methods of packaging and sampling.

SUMMARY AND CONCLUSIONS

Present methods of packaging and handling American cotton are accompanied by substantial economic losses each year, and are subject to adverse criticism in the markets of the world. The sources of these losses and the admittedly justifiable complaints of our for-

eign customers are to a large extent attributable to the processes and practices associated with baling to low density at gins and subsequent recompression to higher densities for shipment. The bales are not well standardized with respect to weight, size, and shape, and lack adequate and suitable covering. The bale covering is mutilated through excessive sampling. The double or triple handling of the bales in recompressing at the compress and the inadequate attention given to appearance and shape of the bales as well as for providing covering for sample holes, are the greatest sources of economic loss. Although practically all elements of the cotton industry recognize that these processes and practices could be so improved as to make American cotton more acceptable in world markets and to effect reductions in marketing costs, no concerted efforts in this direction have been made in the United States, largely because of the inertia resulting from established customs and because of heavy investment in existing equipment.

Present practices in the packaging of American cotton are responsible for a substantial part of the price spread between the grower and the spinner. A large part of this spread consists of costs of physical handling of bales, including transportation, storage, and related services, in which the initial low-density gin package plays an important part. Any substantial reduction in marketing costs must come very largely in this field through improved methods of packaging that will reduce costs of transportation, storage, handling, and other services required in moving the cotton from the gin to the cotton mill. The use of suitable bale covering to eliminate loss and damage to the cotton would also provide worth-while economies.

In general, foreign cotton-producing countries have accomplished substantial progress in packaging cotton. In some of these countries, government regulation, together with a realization on the part of members of the cotton industry that improved packaging enhances the competitive position of their cotton in world markets and creates better consumer demand, is responsible for the superiority of bale packaging. The practice of gin compression employed in many foreign cotton-producing countries, notably Brazil, has paved the way for improvements of their bale package. In the United States, gin compression of cotton to higher density, although put into practice in several instances, has not been successfully adopted. In recent years, however, renewed interest in gin compression as a means for overcoming the criticism of American cotton and making it more acceptable in world markets, as well as for bringing about reductions in marketing costs, has prompted the United States Department of Agriculture to make a comprehensive study of the problem in this country.

These studies were designed to explore the various alternative possibilities of packaging cotton and their respective advantages and disadvantages from the standpoint of engineering feasibility and comparative costs. The ultimate objectives of the studies were: (1) Improved appearance of American cotton bales; (2) better protection against damage, deterioration, and loss; and (3) lowest possible cost of packaging and handling consistent with a thoroughly satisfactory package.

The laboratory studies and tests were conducted at the United

States Cotton Ginning Laboratory located at Stoneville, Miss., and included the following kinds of pressing equipment: A conventional type low-density press for 500-pound bales; a high-density gin press producing 400-pound bales; a round-bale press producing 250-pound bales; and a standard-density gin press with interchangeable press-box dimensions of 20 by 54, 23½ by 54, and 27 by 54 inches and producing 500-pound bales.

The complete investigations provide information with respect to: (1) Mechanical feasibility of gin compression; (2) costs of gin compression as compared with costs of low-density packaging and recompression; (3) effect of gin compression on fiber quality and on acceptability of bales by cotton manufacturers; (4) adaptability of the package to transportation equipment and to the transportation freight-rate structure; and (5) suitability of the package from the standpoint of meeting trade, storage, and handling requirements. After investigating systematically all these factors, the standard-density gin press with 3 hydraulic rams and a 20- by 54-inch box designed to produce 500-pound bales, was found to provide the method of packaging that would most nearly fulfill the needs of the American cotton industry, and be economically adapted to existing gin installations.

A standard-density gin press of suitable engineering design for integration with standard-ginning equipment may be constructed and installed without condenser and tramper at an estimated cost of $5,500. The regular condenser and tramper used with the low-density press may be adapted for use with the standard-density press. The estimated cost of the conventional all-steel low-density gin press is $3,000 without condenser and tramper. The standard-density gin press, therefore, would represent an additional investment of approximately $2,500 in equipping a new gin plant. This expense amortized over a period of 20 years, the estimated life of a press, would represent about $125 per year.

The extra cost per bale would vary inversely with the volume of ginning and, in the case of a replacement of an existing low-density press, with the salvage value of the used press. On a 20-year amortization basis, these extra fixed costs of standard-density gin packaging may range from about 5 cents per bale with a ginning volume of 5,000 bales to 25 cents per bale with a ginning volume of 1,000 bales per season.

The increased operating costs with the standard-density gin press, as compared with the low-density gin press, include repairs, maintenance, and power, with no extra costs for labor required in the operation of the press. These increased costs range from 1.9 cents with an annual volume of 5,000 bales to 2.3 cents with an annual volume of 1,000 bales.

The total increased costs for standard-density gin pressing over low-density pressing, including both fixed and operating costs, will range from about 7 cents per bale on a 5,000 bale-pressing enterprise to about 27 cents per bale on a volume of only 1,000 bales per season.

Standard-density gin packaging showed net savings over low-density gin pressing and subsequent recompression that ranged from about 43 cents per bale on a 1,000-bale gin volume to 63 cents per bale with an annual volume of 5,000 bales.

Up-packing, 2-story hydraulic presses, designed for the conventional low-density bales, may be converted to standard density presses by strengthening the frame and box parts and adding two rams and lengthening the triple-ram assembly to permit a 90-inch stroke. Factory-built parts for the press conversion could be made available at prices within the reach of the gin owner. Actual cost of making the conversion will depend upon a number of factors, including types of existing frame, cotton and press box construction, doors, tramper, and pumping outfit.

Such a press was installed in 1942 and successfully operated during the 1942, 1943, and 1944 seasons at a 4-80 gin plant in the Mississippi Delta. The plant handled a total volume of 3,300 bales, with a pressing and tying-out capacity of about 6 minutes per bale, which is well within the ginning capacity of 5-80 gin outfits. Another converted press that operated satisfactorily in a gin in the Mesilla Valley of New Mexico in 1943 and 1944, pressed a total of 3,600 bales to standard density, or an average density about 60 percent higher than that for low-density gin pressing under similar conditions.

The standard-density 500-pound gin bale is neat in appearance, provides a suitable package from the standpoint of storage, handling, and transportation, and is satisfactory from the standpoint of opening and processing at mills. Laboratory spinning tests, and observations at a domestic mill, have shown that gin compression of rectangular bales does not damage the spinning value of the cotton and that the bales meet opening room and other mill requirements.

Any of the customary types of bagging employed at gins may be used on the gin-compressed bales, but the closely woven bagging fabrics are more desirable, as they provide better protection to the bale contents, as well as better bale appearance. The bagging dimensions should be 50 by 90 inches in order to provide for a complete coverage of the bale. Eight 1½-pound ties, 114 inches long, folded for reinforcement at the buckle, have been found to be suitable for use in tying the standard-density gin bales without increasing bale tare. Eleven ties of No. 9 gage steel wire might be required to hold the density on bales pressed in the more arid regions. The use of folds at the end of the flat bands, however, provides a double thickness at these points and prevents undue slippage and shearing at the buckles. So long as present sampling practices are employed, the spacing of tie channels in the press platens should be such as to permit adequate space on the faces of the bale between bands for the cutting of cotton samples.

Except for export cotton, the adoption of standard-density gin compression would obviate the need for recompression of bales. This would, in some instances, encourage the practice of making direct shipment from gins to mills and would possibly stimulate an interest in the construction or acquisition of warehousing facilities at or near gins, provided compress establishments continued to make a delivery charge for bales not compressed by them. Otherwise, it is not anticipated that the structure and functions of the present cotton-marketing system would be affected materially by the adoption of gin compression. Significant reduction in the spread between prices received by cotton growers and prices paid

by cotton spinners would, however, be affected by this change in packaging methods.

In areas that grow cotton on a standardized-variety basis, gin compression would tend to bring about more satisfactory methods of sampling of bales at gins and pave the way for the adoption of mechanical sampling with automatic equipment recently developed for this purpose. The use of this equipment would make unnecessary the cutting of bales for samples, and would obviate the need for the application of patches, thereby contributing to improvement in the appearance of American bales.

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